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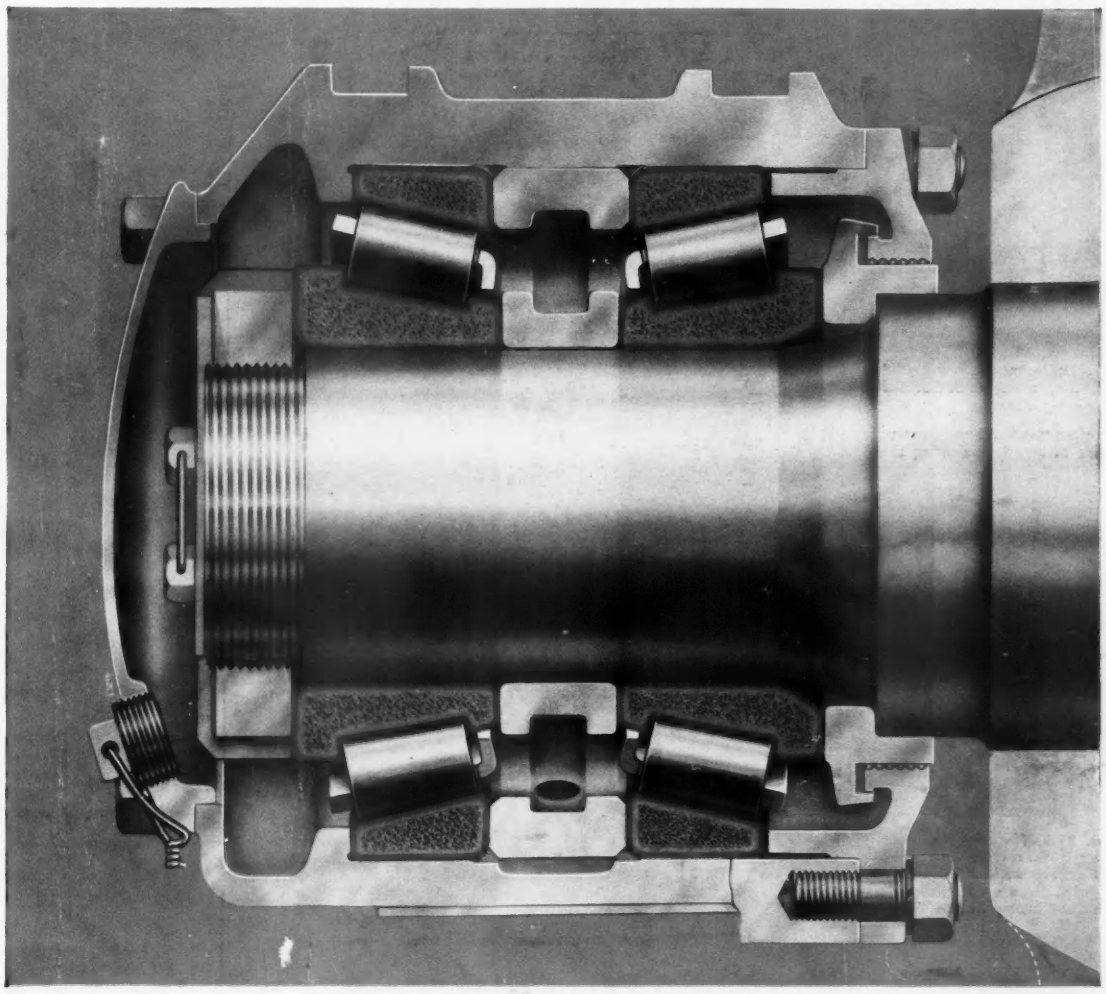

TRADE MARK TIMKEN

FOR RAILWAY AND OTHER HEAVY DUTIES

Timken Tapered Roller Bearings, with their high capacity for carrying journal and thrust loads, are being used to an increasing extent for railway work.

The upper illustration shows a 'phantom' view of a typical 'indirect-mounted' Timken axle-box, and on the right are shown respectively, a Timken cannon-box on the L.M.S. Turbomotive: a typical dual race Timken axle-box ('direct' mounted) and below, an illustration of a bogie of the Sentinel-Cammell Steam Rail-car, where Timken tapered roller bearings are used, not only for the axle-boxes but also for the main axle gearing.

Timken tapered roller bearings are employed on important undertakings all over the world and are being incorporated in many new designs where high efficiency and low maintenance costs are of paramount importance.

Particulars of Timken tapered roller bearings will be sent on request, also the new Timken catalogue dealing with ball and parallel roller bearings manufactured by the company.

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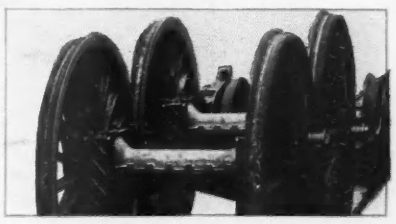
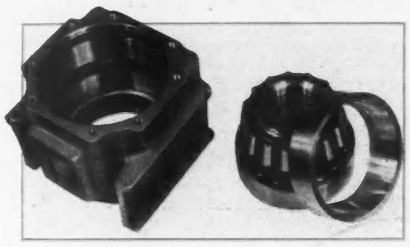
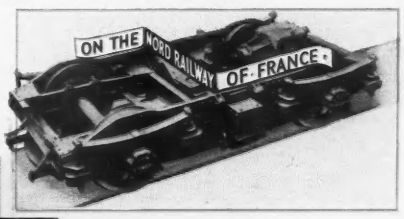


Timken cannon-box on L.M.S. Turbomotive.



With Timken axle-boxes and transmission-gear bearings.



A Timken axle-box.

TIMKEN TAPERED ROLLER BEARINGS

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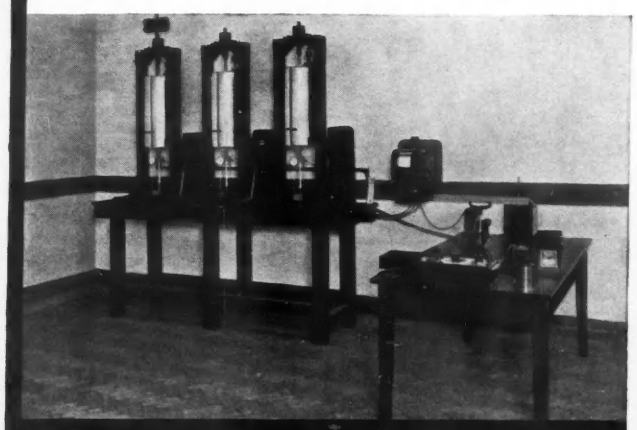
CREEP TESTING

CREEP TESTING LABORATORY. Long-time and accelerated tests on the behaviour of engineering materials at elevated temperatures.

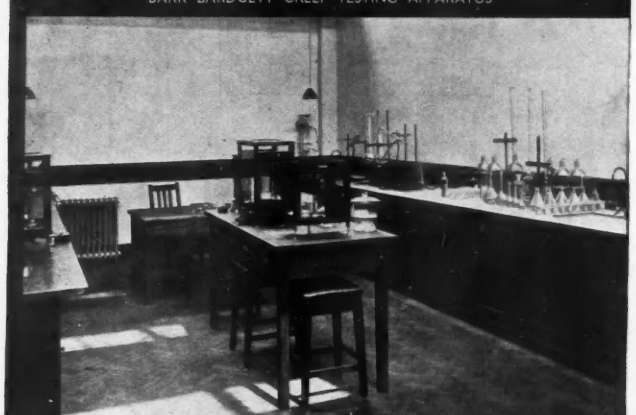
The illustration shows the short-time creep testing apparatus which we find a valuable means of rapidly indicating the creep resisting properties.



BARR-BARDGETT CREEP TESTING APPARATUS

CORROSION TESTING

CORROSION TESTING LABORATORY with atmospheric testing station attached, for research into corrosion problems. Tests are carried out not only on the well-known "Silver Fox" stainless varieties of steel, but also on the weather-resisting steels of the "Kuplus" and "Chrome-Kuplus" types



CORROSION TESTING LABORATORY

PHYSICAL TESTING

Section of the PHYSICS LAEORATORY for examination cf magnetic and electrical properties (the latter at normal and elevated temperatures), dilatometry, thermal conductivity, etc.

At the end is seen the laboratory for microscopical examination (complete with dark room), equipped with the most modern type of apparatus.

NORTH END OF PHYSICS LABORATORY

A brochure has been prepared (Ref. No. U.S.C. 167) giving an account of the facilities available for researches into new processes and materials; write to Central Research Laboratories, The United Steel Companies Ltd., Stocksbridge, Nr. Sheffield.

CENTRAL RESEARCH DEPARTMENT

THE UNITED STEEL COMPANIES LTD

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THE UNITED STEEL COMPANIES LIMITED

A Seven-Day Journal

Wireless Facilities for Italian Ships.

The use of short-wave telephony sets for ship-to-shore communication has increased greatly, owing to recent research. The Italian Government has just improved the facilities available in this respect by the provision at Coltano of a new Marconi type short-wave transmitter with a wave range of 13–100 m. Particular attention has been paid to high quality of speech in the installation, which has an output to the aerial feeders of 56 kW maximum for telegraphy and 35 kW at 80 per cent. modulation for telephony. This makes the installation one of the most powerful in the world. A linear speech response within plus or minus 2 decibels over a band of 50–10,000 cycles has been arranged, this wide speech response giving great clearness to the transmitted word and allowing the service to be available for musical programmes. Four spot waves are provided, and are selected by means of a turntable mechanism which brings into circuit the correct tuning inductances and condensers, making a change of wavelength exceedingly rapid. The stabilisation of the transmitter has been carried out with great care. Two of the spot waves have a master oscillator with a stability of 1 in 50,000. The other two have a stability of 1 in 20,000, so that in this respect international legislation has been fully complied with. Four vertical "uniform" aerials are used, each for a different wavelength. These aerials are connected with the transmitter by copper concentric feeders. The change over from one aerial to the other is made by remote control.

International Rationalisation of Shipping.

The International Shipping Conference has now received replies from all the constituent Associations, except the United States, giving their comments on the draft scheme of rationalisation of shipping prepared by the first preliminary Conference in January. All the countries which have replied accept the principle of rationalisation and recognise the need for some form of co-operative action to adjust the supply of tonnage to the demand. Most of the replies are in the form of criticisms and suggestions for the improvement of the scheme as drafted. Two countries, Great Britain and Japan, suggest the adoption of alternative schemes instead of the original scheme. In particular, the Chamber of Shipping and Liverpool Steamship Owners' Association in a joint letter to the Conference submit a draft voluntary non-contributory scheme, the broad principle of which is that owners would agree to lay up an agreed percentage of tonnage as ascertained at an agreed date. The Conference still hopes to receive a reply from the American shipowners, but in the meantime, as all other countries have submitted their observations, these have been circulated to the constituent Associations for examination with a view to a further preliminary meeting in October. When the Associations have been able to consider the position as reflected in the replies, more definite arrangements for such a meeting will be made.

Social Credit in Alberta.

It seems likely that the Province of Alberta in Canada will be the scene of the world's first Social Credit Government. According to news from Edmonton, a complete majority has now been gained by the Social Credit candidates. The count under the proportional system of balloting is still proceeding as we go to press, but the latest returns show the following state of parties :—Social Credit, 47 ; Liberal, 5 ; Conservative, 2. As the writs are, however, not returnable until September 1st, the Social Credit party has not yet been officially elected, but it is now in process of being formed. On Saturday, August 25th, Mr. Reid, the present Premier, handed to the Lieutenant-Governor the written resignation of his Ministry, which, however, was declined until the new party has been formed. The leader of the Social Credit party is Mr. William Aberhart, of California, who himself is not a candidate. The Aberhart system of Social Credit differs in some important respects from that of Major Douglas. There seems no reason to doubt that an important factor in the election was Mr. Aberhart's promise of a basic monthly dividend of at least 25 dollars to each adult, which is to be secured by an unearned increment levy on all transactions. Mr. Aberhart has been invited to form a Cabinet, and it seems likely that if this is done he will assume office on Tuesday, September 3rd.

The Proposed Forth Road Bridge.

In a Journal note of August 16th we referred to a report on the Mackintosh Rock site for the proposed Forth road bridge which has been prepared by Messrs. Mott, Hay and Anderson, of Westminster. That report has, we understand, now been received by the Town Clerk of Edinburgh. The report, which, it is understood, is generally favourable, states that there would be no difficulty in obtaining a satisfactory foundation at a reasonable depth, and that economies could be effected in the estimated cost of £3,650,000, reducing it to £3,260,000. The borings showed more favourable strata than was assumed when the original estimates were made, and the foundations therefore need not be sunk to such depths as were contemplated. Steel rope manufacturers have recently submitted very favourable quotations for the supply of steel rope, which would be involved in the main span of 3000ft. The proposed bridge would be of the suspension type, with a minimum vertical clearance for shipping of 150ft. above high water. The bridge would have a carriageway of 30ft., and two footpaths, each 5ft. wide. The engineers also state that both the proposed bridge at the Mackintosh Rock site and the alternative one proposed at Rosyth are now on a similar basis from a technical point of view.

Automobile Research and Standardisation.

The fourth annual report of the Research and Standardisation Committee of the Institution of Automobile Engineers, which has just been issued, shows an increasing interest in co-operative research in the British automobile industry. From July, 1934, to June, 1935, the affiliated membership of the Committee increased from 144 to 163 members. The annual expenditure on research rose from £6116 in 1933–34 to £8508 in 1934–35. It is pointed out that whereas up to June, 1934, the income was expended both on research and standardisation, that of the past year has been available entirely for research. The provision of a new and larger laboratory is contemplated in order to deal with the work now in hand and that to be undertaken. The main investigations at present in progress at the Committee's Chiswick Laboratory include such subjects as cylinder and valve seat wear, cracking of bearings, frictional and wearing properties of brake linings and drums, brake squeak, and the corrosion of ball bearings in storage. Outside work includes an investigation into lubricating oil consumption at the Ricardo Laboratories, piston temperature research at Manchester University, and road impact investigations at the National Physical Laboratory. Research has also been undertaken at Teddington on the fatigue of cast crankshaft materials. From the above summary it is clear that the work undertaken is directly beneficial to vehicle operators and the general public, and this fact, the report states, is in itself a justification for the contribution of public funds in the form of a Government grant towards the cost of the work, while operating interests should realise increasingly how much they stand to benefit from the results of this important scheme of co-operative research.

New L.N.E.R. Water-Softening Plants.

The London and North-Eastern Railway Company is installing twenty-two further water-softening plants at various points on its system. Thirteen of the new plants are to be built between King's Cross and Doncaster, and sites for the remainder have been chosen on the Great Eastern section of the line. When all are completed there will be forty such plants in operation in the company's eastern and southern areas, with a total designed capacity for treating three thousand million gallons of water a year. These plants, it is calculated, will prevent scale formation in locomotive boilers to the extent of about 4000 tons. In a hard water district some hundredweights of scale are often found in a boiler of a locomotive after 50,000 miles of service, and although frequent washing out removes the soft and loose material, subsequent descaling now forms a substantial proportion of the cost of a general overhaul. Numerous experiments carried out by the company's mechanical engineers and chemists have been successful in reducing by softening plants 45 deg. of hardness to only 2 deg. The plants now being installed each have a capacity of from 5000 to 40,000 gallons per hour, and comprise filtering and storage vessels, the storage containers being housed in round steel towers.

The Late Professor Henry Briggs.

The profession of mining engineering has lost one of its leading members by the death of Dr. Henry Briggs, the first Hood Professor of Mining in the University of Edinburgh. Dr. Briggs, who died in a nursing home in London on Saturday, August 24th, was only fifty-two years of age. He was educated at Bradford, and studied at the Royal College of Science and the Royal School of Mines, following which he obtained experience in mining in Yorkshire, Cumberland, and Wales. In 1905 he was appointed Lecturer in Mine Surveying at the University of Birmingham, and Lecturer in Mining for Warwickshire. Two years later he joined the staff of the Heriot Watt College, Edinburgh, and in 1919 was appointed Professor of Mining at that institution. In 1924 he was appointed to the Hood Chair of Mining at Edinburgh University. He took a prominent part in Government and public work, and in 1914 advised the Board of Trade on British barytes resources. During the war he was Experimental Director of Mine Rescue Research, and undertook experimental work relating to trench and mine warfare for the War Office. He was Founder and Director of the Military Test Station at Edinburgh in 1918, and was a valued member of the Oxygen Research Committee. In connection with the development of home fuel resources, he served as Chairman of the Oil from Coal Development Committee of the Scottish National Development Council. Professor Briggs was a D.Sc. of Birmingham University, and a Ph.D. of the University of Edinburgh, and was a member of many scientific institutions and technical societies. His death at such a comparatively early age will be deeply regretted by many friends, both in this country, on the Continent, and throughout the Empire, where his work was known and valued.

The Safety in Mines Research Board.

The annual report of the Safety in Mines Research Board for the year 1934 has now been published. It states that the work of the Board has become of such interest to mine workers that the exhibition hall at the Buxton research station is no longer adequate to accommodate the number of visitors nor the number of exhibits. The model coal face has been rearranged to show modern methods of roof support at a machine-worked face. The explosives re-cartridging building was completed in June, and now forms a model of what such "danger" buildings should be, besides being of great service to the research and testing staffs. Tests which have been carried out on pre-cast concrete lining arches used extensively in sewerage work in this country have been completed. A section, 7ft. long, and 7ft. 10in. internal diameter, was tested. The tests showed that there is little difference from the point of view of resistance between these arches and rail steel arches lined with brickwork. Investigations on wire ropes have been continued at the Imperial College of Science and Technology under Dr. Hogan. Close touch was maintained with the Wire Ropes Research Committee of the Institution of Mechanical Engineers, with the B.S.I., and various Continental organisations. Various forms of deterioration in ropes were studied, and some interesting figures obtained. Some useful papers are included in the report on various problems of mine technology, both from the chemist's and the engineer's points of view.

The British Gliding Association Meeting.

The national meeting of the British Gliding Association began at Sutton Bank, near Thirsk, in Yorkshire, on Saturday, August 24th, and will continue for nine days. Unfortunately, the weather was not suitable during the first day, as after the previous day's rain an easterly breeze sprang up and continued through the day. One or two flights were made, but with no attempt at record flying. On Sunday an accident marred the proceedings. A Scud II machine owned and flown by Mr. I. F. Harris, of Belfast, fell from a height of about 50ft., the owner sustaining serious injuries. Up to Tuesday, although some fifteen flights were made, no serious flying was attempted, owing to adverse weather conditions. A projected flight over a 15-mile course was begun, but was abandoned as sufficient height could not be attained. Although three pilots were in the air for an hour and a half, a height of 1500ft. was the maximum reached. After a stormy night, the fourth day (Wednesday) was favoured with good conditions for soaring. Three pilots landed in various parts of East Yorkshire after flying distances of from 20 to 61 miles, and one craft reached a height of 5000ft. It is hoped that before the end of the meeting attempts will be made to win the Wakefield Trophy for distance, the de Havilland Cup for height, and the Volk Cup for duration of flight, but at present the weather conditions are adverse. In addition, a cup is to be presented for the best out-and-return flight at the meeting.

The Anti-Noise Campaign.

The first annual report of the Anti-Noise League, issued this week, emphasises the progress made in the elimination of unnecessary noise from town life, and points out the still greater work yet to be done, which, however, is handicapped by financial limitations. To the criticism that noise has always existed in towns, the report replies that traffic noises have grown more penetrating, more strident, and more unrhythmically continuous during the past twenty years. The criticism that the ill-effects of noise upon human beings cannot be scientifically assessed is answered by medical evidence giving the cost in terms of nervous disorder. The difficulty due to the lack of a simple universally accepted instrument for measuring noise which can be used away from the laboratory militates against the enforcement of definite laws against a set "value of noise," but the creation of an enlightened public opinion can, it states, with the assistance of experts, do even more than legislation. The report points out that the Oxford Conference of the League passed resolutions asking for still further limitations to be placed on the use of the motor horn and aiming at its eventual abolition except in emergency. The report praises the action of the Westminster City Council in permitting the extra cost of road drill silencers to be added to quotations by contractors.

Electric Driving.

No. II.

(Continued from page 185, August 23rd.)

THE torque required during acceleration from rest to full speed is the main point to be kept in view when considering the question of what type of motor should be employed for driving a given machine. Another factor that must not be overlooked is the amount of starting current likely to be drawn from the supply mains. Squirrel-cage and slip-ring motors differ in that while the former has a rotor of fixed electrical characteristics and consequently an unchangeable starting and running performance, by inserting resistance in the rotor circuit of a slip-ring machine, it is possible to vary the performance over a wide range. While simplicity is the chief advantage of the squirrel-cage machine, that of the slip-ring motor is flexibility. By the use of high resistance and double-deck or Boucherot rotors, the squirrel-cage motor has been made to give a higher starting torque per ampère of starting current than is obtainable with the standard squirrel-cage machine. These motors are consequently now often employed for drives which at one time necessitated a slip-ring motor. High resistance rotors give a good current torque ratio and a power factor equal to that of a standard motor, but the increased rotor loss naturally lowers the efficiency. Motors with high resistance rotors are therefore most suitable for duties that involve frequent starting and stopping and comparative short load periods. Double-deck or Boucherot rotors (Fig. 9) have two sets of conductors, an outer set, having a high resistance and low reactance to give the desired starting characteristics, and an inner set, having a low resistance and high reactance, to carry the major portion of the current on full load. At starting the frequency in the rotor is the line frequency and the high reactance of the inner cage produces a choking effect, which prevents current flowing in this winding. The outer cage with high resistance develops a high starting torque with a current depending largely on the value of its resistance. But, as the rotor accelerates and approaches synchronism, the frequency of the E.M.F. generated in its conductors falls and the choking effect of the inner cage is reduced until finally when near synchronism the rotor operates with the characteristics of an ordinary low-resistance rotor. The effect therefore is to produce a machine having a high starting torque with a high running efficiency.

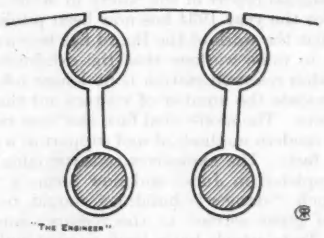


FIG. 9—SECTION THROUGH DOUBLE ROTOR WINDING

While this type of machine has an efficiency equal to that of a standard motor, the power factor is apt to be somewhat lower, particularly when too low a current torque ratio is aimed at and in the case of slow-speed motors. But for normal speeds of 1500, 1000, 750, and 600 r.p.m. and outputs of about 4 h.p. per pole and upwards, the power factor is not as a rule appreciably below that of a corresponding slip-ring motor.

The speed-torque characteristics of an ordinary G.E.C. squirrel-cage motor are shown in Fig. 10, the speed-current curve of such a motor in Fig. 11, the speed-torque curves of a slip-ring motor for different rotor resistances in Fig. 12, and characteristic curves for a high torque squirrel-cage motor in Fig. 13, in which A is the speed-torque curve and B the speed-current curve; C is the speed-torque curve for a straight squirrel-cage motor. Speed-torque characteristics can be altered in shape by different proportions of the rotor slots. Among the firms manufacturing high-torque squirrel-cage motors are the G.E.C., Lancashire Dynamo and Electromotors, Ltd., Higgs Motors, Ltd., and Veritys, Ltd., which supplies the Verity Heemaf machine from 3 h.p. and upwards. It has two sets of squirrel-cage conductors similar to the Boucherot machine, but it is claimed that owing to a modification the high torque is obtained without affecting the power factor. A high torque motor of this type driving a punching and shearing machine is shown in Fig. 14.

As regards methods of starting motors, slip-ring machines can, of course, be brought up to speed by a rotor resistance starter, which may be hand or automatically operated by means of contactor gear. Automatically controlled motors may be operated by a push-button, limit switch, or float switch at the most convenient point. The simplest method of starting a squirrel-cage motor is to switch it directly on the line, but the permissible starting current may vary considerably in different cases. The determining factors are the horse-power of the motor concerned and its position on the supply system, *i.e.*, whether on a main feeder close to the source of supply or on a feeder in an outlying district. The permissible current also depends on whether the consumer takes a small amount of power at low pressure or a bulk H.T. supply. All these factors govern the supply undertaking's regulations, and in the case of a low-tension supply, it may happen that direct starting is not permitted with motors above 3 h.p. But a considerably higher limit is permissible when works take a bulk supply. The actual size of motor depends on the total load. In power stations and on private supply systems, such as those associated with collieries, works, &c., the limit for direct switching may be 100 h.p., or more. Occasionally, squirrel-cage motors are started by a resistance starter in series with the stator winding, a star-connected stator with the starter in the neutral being the simplest arrangement. While the starting current required for a given torque is high, the scheme is suitable for starting small motors for driving hoists, &c. When squirrel-cage motors are started at reduced voltages, it is more usual to employ an auto-transformer.

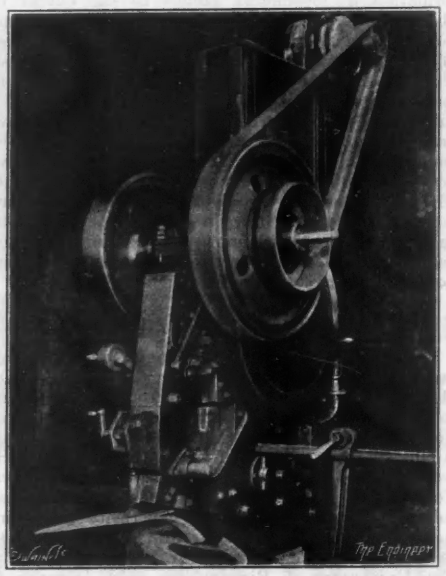


FIG. 14—ELECTRICALLY-DRIVEN PUNCHING AND SHEARING MACHINE

The current from the line and the starting torque are reduced in proportion to the square of the transformer tapping voltage applied to the motor. A method of connecting an auto-transformer in open delta for motor starting is shown in Fig. 15 *a*, while Fig. 15 *b* shows the values of the current in the starter and the line on the assumption that use is made of a 60 per cent. tapping. A more common method of starting squirrel-cage motors is to employ a star-delta starter which gives the same result as an auto-transformer with a $\frac{1}{\sqrt{3}}$, or 58 per cent., tapping. Compared with the auto-transformer method the scheme is simpler and cheaper, and it draws no magnetising current. The star and mesh connections used for starting and running respectively, and the values of volts and current per phase are given in Fig. 16, which shows that the torque and current are one-third of the values obtained when direct switching is employed.

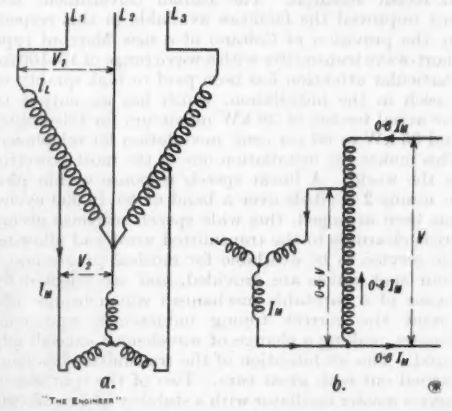
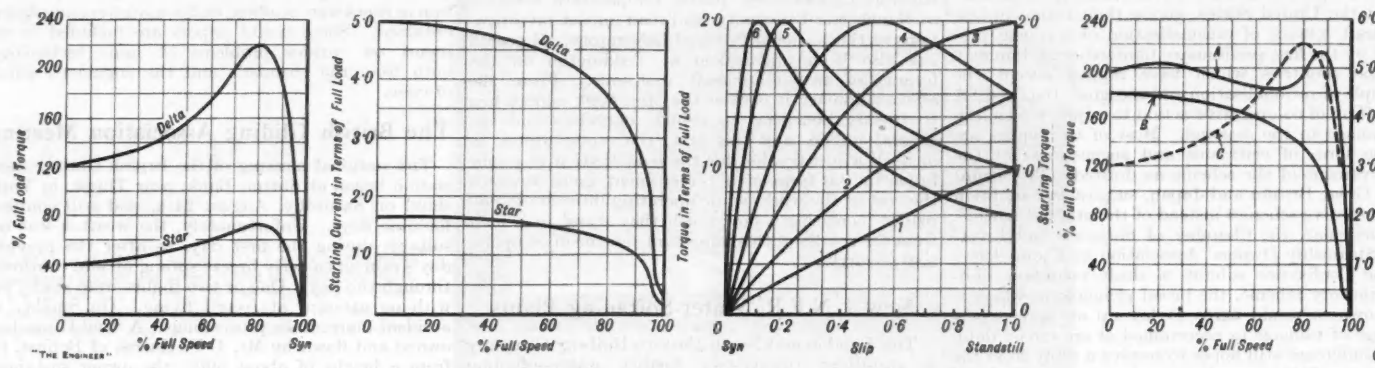


FIG. 15—AUTO-TRANSFORMER STARTER CONNECTIONS

This method of starting obviously necessitates bringing each end of each phase winding out of the motor case, whereas direct switching, or auto-transformer starting, merely necessitates permanently connecting the stator windings in star or mesh, and three main terminals therefore suffice. Where the torque required when starting a motor on public supply mains is in the neighbourhood of 40 per cent. full-load torque, and a current 1·75 times full-load current is permissible, a squirrel-cage motor with a star-delta starter is generally satisfactory, although motors of 3 h.p. and, under the conditions mentioned, much more powerful machines may be switched directly on to the line. When the size of a motor necessitates a considerable reduction in the starting current, or where a heavy starting torque is required, a slip-ring motor should be employed. Where a bulk supply is taken motors of 20 h.p. or more may



FIGS. 10 TO 13—CHARACTERISTIC CURVES OF INDUCTION MOTORS

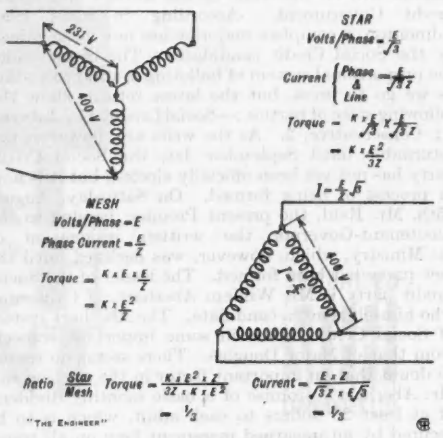

STAR
Volts/Phase = E/√3
Current (Phase & Line) = E/√3Z
Torque = K x E/√3 x E/√3Z = K x E²/3Z
MESH
Volts/Phase = E
Phase Current = E/Z
Torque = K x E x E/Z = K x E²/Z
Ratio Star/Mesh Torque = K x E² x Z / 3Z x K x E² = 1/3
Current = E x Z / √3Z x E√3 = 1/3
231 V
400 V

FIG. 16—STAR-DELTA CONNECTIONS

usually be switched directly on to the line. According to the torque required larger squirrel-cage machines may either be started with a star-delta starter or an auto-transformer. Many ordinary squirrel-cage motors have been fitted with automatic clutches as made, for example, by Thomas Broadbent and Sons, Ltd., of Huddersfield. The clutch is adjusted to pick up the load gradually and without shock, as the motor attains its full speed. It is possible in this way to reduce the torque required at starting and thus to enable some form of starter to be used to lower the starting current. The clutch can also serve as a safety device in the event of an overload, for the shoes can be made to limit the torque that can be transmitted.

While it is scarcely possible to lay down hard and fast rules governing the type of motor that should be employed for driving all machines, in most cases it is not difficult to decide whether a slip-ring, ordinary squirrel-cage, or high-torque squirrel-cage motor should be adopted. In dealing with the selection of a suitable motor and starter, the matter will be considered here from the point of view of load conditions alone, and not with regard to restrictions governing starting current. Beginning with slip-ring motors, it can be shown that when accelerating the total power lost in the rotor circuit of an induction motor is equal to the kinetic energy of the plant driven at full speed. The rotor loss appears as heat which has to be dissipated. As the rotor current is always balanced by an equivalent current in the stator if the rotor current is high the stator loss will also be high, and if the starting period be long an inconvenient amount of heat will be generated in the stator. Thus, it follows that plant having appreciable fly-wheel effect should be driven by a slip-ring motor. Rotor loss equal to the kinetic energy will then be divided between the rotor and starting resistance which will take the major part. The rotor current can be reduced to the minimum value consistent with the acceleration required, and the stator loss will also be reduced to a minimum. As rolling mills are generally fitted with fly-wheels to equalise the widely fluctuating load caused by the passage of the billet through the rolls and to maintain the power taken from the mains comparatively constant, they belong to the class of machine needing slip-ring motors, which have the additional necessary characteristic of a falling speed torque characteristic to enable the fly-wheel to give up its kinetic energy to the load by the insertion of a permanent or slip resistance in the rotor circuit. A 1000 h.p. A.C. motor, made by the General Electric Company, driving plate mills is shown in Fig. 17. The drive is transmitted through gearing, and two balancing fly-wheels are coupled to the motor shaft. Among other machines driven by slip-ring motors are low-speed fans with large diameter rotors which introduce an appreciable fly-wheel effect.

But apart from the question of fly-wheel effect, slip-ring motors are often necessary to obtain a heavy torque during the starting period. Reciprocating pumps and large compressors, for example, offer a high and irregular opposing torque at starting, the period of maximum torque occurring on the compression stroke. Tube and ball mills in the cement and ore-crushing industries also demand a torque considerably in excess of the full-load value, and need slip-ring motors. When frequent starting and stopping without mechanical shocks, and accurate control are necessary, as on electric coal winders working to a fairly definite time schedule, this type of motor gives the requisite control.

According to the weight to be hauled, the slope of workings and the number of trips per hour, the duty of haulage motors used extensively in the mining and quarrying industries varies considerably. Generally, the duty consists of accelerating and hauling loaded tubes up an incline by means of a rope wound on a drum driven through gearing, and the normal torque required for accelerating may vary between 1½ and twice full load, whilst in the event of an obstruction on the rails, it may be even higher. Here, again, a slip-ring motor meets the requirements. The smooth control of this type of machine makes it suitable for cranes hoisting fragile goods, such as glassware, although inching can be secured to some extent on small sized cranes handling coal, &c., with the aid of two-speed squirrel-cage motors. Motors of appreciable size that have to be reversed at frequent intervals, such as a live roll motor for handling hot ingots between the passes through the rolling mill, should be of the slip-ring type, although, if the losses over the whole duty cycle can be dissipated by a squirrel-cage motor, that type of machine may be employed. But both as the result of experience and relaxations by supply undertakings of the rules governing starting currents, squirrel-cage motors are now installed on an extensive scale. They are employed, for example, for driving line shafting, centrifugal pumps, high-speed fans, small compressors fitted with an unloading device, many machine tools in the engineering and other industries, endless rope haulages with friction clutches, small conveyors, and motor generator sets.

FIG. 17—1000 H.P. A.C. MOTOR DRIVING PLATE MILLS

The torque required in starting up a centrifugal pump is shown in Fig. 18, which represents a high-efficiency Rees-Roturbo pump taking 100 to 150 h.p. The torque may be regarded as consisting of two components: (*a*) the frictional torque, arising chiefly from the glands and bearings, having a value at starting of about 30 per cent. of the full-load torque and falling away as the pump speeds up; and (*b*) the hydraulic torque, which is zero at starting and increases in accordance with an approximately square law as the speed of the pump rises. It reaches full-load torque at full speed with the delivery valve open and about 50 per cent. full-load torque with it shut. Superimposed on these curves is the speed torque curve for a star-delta started motor, which is equivalent to one started with an auto-transformer on a 60 per cent. tapping. The curves show that a pump with these characteristics can be started by a squirrel-cage motor provided the discharge valve is shut.

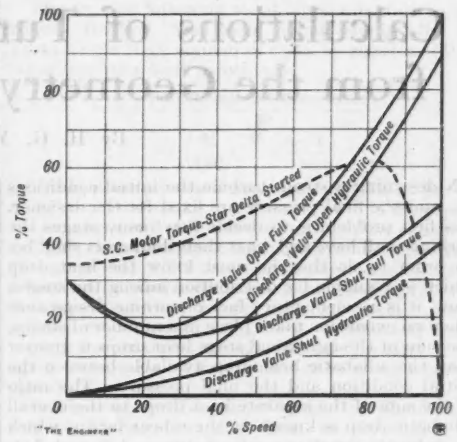


FIG. 18—SPEED-TORQUE CHARACTERISTICS OF PUMP DRIVE

High torque motors come between the ordinary squirrel-cage and slip machines, their chief advantage being their ability to improve starting conditions. The starting torque of the Verity Heemaf motors is said to vary between 180–300 per cent. full-load torque when switched directly on to the line, whilst taking 390–525 per cent. full-load current, according to size. With star-delta starting the starting torque is claimed to vary from 60–100 per cent., the full-load value with 130–175 per cent. full-load current. High torque motors have a wide field of application. Not only can they be used for all the drives mentioned in connection with ordinary squirrel-cage motors when it is desired to reduce the starting current, but also when the starting torque required exceeds that of a straight squirrel-cage machine. In individual cases the starting torque needed for line shafting fans, machine tools, and conveyors may be beyond the capacity of a simple squirrel-cage motor, yet not sufficiently high to justify a slip-ring machine, and a high torque motor with a star-delta starter then offers a considerably cheaper alternative.

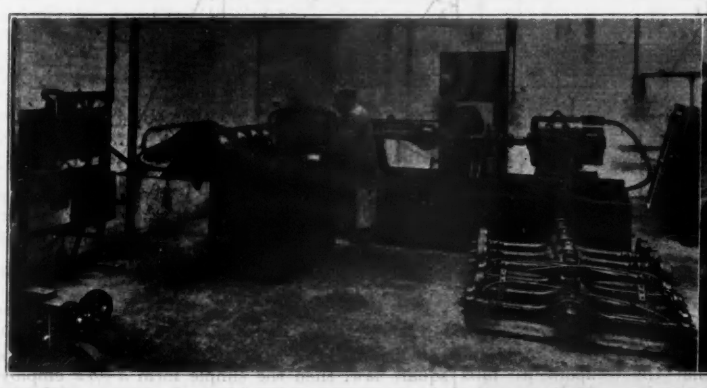


FIG. 19—BACK AXLE TESTING SET

FIG. 20—REAR VIEW OF BACK AXLE TESTING SET

As D.C. has long been gradually giving place to A.C. for industrial electric driving, it is not proposed to pay much attention to D.C. motors, although it must be admitted that in some cases they offer advantages. The D.C. system readily lends itself to certain special applications, such as mechanical testing, as exemplified by the illustrations Figs. 19 and 20, which show a back axle testing set supplied by the General Electric Company to the Moss Gear Company, Ltd. It consists of two 25 h.p., 220-volt, 580–875 r.p.m. motors and one 50 h.p., 220-volt, 3500 r.p.m. machine (all designed for D.C.), a main control panel and an

isolating switch. The general arrangement is self-explanatory, but the precise method of carrying out a test calls for a few words. On moving the main controller handle on the control panel the machine coupled to the cardan shaft starts as a motor. Further movement of the controller causes this machine to run at full speed, when the machines which take the place of the road wheels and which are connected in accordance with the Hopkinson scheme act as generators and return power to the supply. Normal running conditions of a road vehicle are therefore established.

Still further movement of the controller reverses the load direction and the machines representing the road wheels act as motors and drive the cardan shaft machine as a generator, which returns current to the supply system. In this way an over-running torque is produced corresponding to the conditions that prevail when a vehicle is running downhill. On continuing to rotate the controller hand wheel the speed of the equipment is reduced to zero and the test cycle is completed. Instruments are provided to indicate the load on the axle shafts, the out-of-balance speed of the road wheels, and the speed of the cardan shaft. Additional control enables the axle torque to be varied between given limits. By means of a rheostat the maximum speed of the cardan shaft can be fixed at any desired value. Perfect speed balance is normally maintained between the two road machines, but an out-of-balance speed can readily be obtained on either machine to reproduce the effects of a vehicle cornering. As it is essential for the tester to be able to detect any noise emanating from the gears, silent operation is an essential feature of the electrical machines.

(To be continued.)

Calculations of Turbine Reheat Factor from the Geometry of the Heat Chart.

By H. G. YATES, M.A.

IN designing a steam turbine the initial conditions and the final pressure are fixed for the designer. His first problem is to decide how many stages the turbine shall have and what their diameters shall be. In order to do this, he must know the heat drop which is available for distribution among the stages. Now, it is an elementary fact of turbine design that when an expansion takes place in a number of stages, the sum of the individual stage heat drops is greater than the adiabatic heat drop available between the initial condition and the final pressure. The ratio of the sum of the separate heat drops to the overall adiabatic drop is known as the reheat factor, which in ordinary practice varies between 1·0 and 1·1, the value being dependent upon certain conditions to be discussed later, foremost among these conditions being the internal efficiency ratio.

The designer, then, desires at an early stage in his work an approximate value of the reheat factor, and, furthermore, he must be able to obtain an accurate value when the design is nearing completion. This article describes a new method by which the designer may calculate the reheat factor corresponding to an assumed internal efficiency, and may later on correct this value when more accurate knowledge of the internal efficiency is available. The method will also be found of use in comparing the efficiencies of turbines operating on different steam conditions.

The calculation of the reheat factor for an infinite number of stages is given in text-books on the properties of steam, but this calculation suffers from certain drawbacks. Quite apart from any question of accuracy, the result is difficult to apply in an actual problem, and, in addition, only holds for an infinite number of stages. The method to be described here deals with the problem on quite different lines, and overcomes both drawbacks.

The method usually adopted in turbine design consists in laying down the separate stages on a Mollier heat chart, and finding the sum of the individual heat drops by adding up the values scaled from the chart. From this point of view, the problem of calculating reheat becomes purely a problem on the geometry of the heat chart. Lines are drawn (see Fig. 1) alternately parallel to adiabatics and to isobars, such that every alternate line terminates on the expansion line which represents the state of the steam at the various stage points. The resulting series of triangles depends upon the expansion line taken, and upon the relative slopes of the isobars—a matter of geometry; and it will be shown that the geometry of the heat chart does admit of analytical treatment.

Now it is well known that for superheated steam at constant pressure the rate of change of entropy with respect to total heat is equal to the inverse of the absolute temperature; that is

$$\left[\frac{\partial \varphi}{\partial H}\right]_p = \frac{1}{T}$$

This rate of change clearly represents the slope of the isobar, namely, the tangent of the angle between the isobar and the adiabatic, with the exception of a scale factor. On the chart generally used in this country, 1 mm. represents one unit of total heat, and 1 mm. in the perpendicular direction represents 0·001 units of entropy. Hence, after allowing for this scale factor, we have

$$\text{Slope of isobar} = \frac{1000}{T}$$

where T is the absolute temperature at the point considered. The isothermals, in fact, form the isoclinal system of the isobars, and all isobars have the same slope at the points where they intersect a given isothermal. This may easily be verified from the heat chart. For example, all the isobars have an inclination of 45 deg. at the points where they intersect the isothermal corresponding to 540 deg. Fah. (approximately 1000 deg. Fah. absolute). Note that in the wet region the slope of any one isobar is constant, and is equal to $\frac{1000}{T_s}$, where T_s is the absolute saturation temperature corresponding to the pressure.

In the method of calculation of reheat factor for an infinite number of stages, as given in text-books, a constant stage efficiency is usually assumed. In what follows, however, we shall assume a straight expansion line. This is approximately the case which generally occurs in practice in an impulse turbine, where the stage efficiency usually increases from one stage to the next, owing to the decrease in leakage, friction, and other losses. If it is desired to apply the results to a curved expansion line, the line may be subdivided into two parts (or more if the curvature is very marked), and the reheat calculated for each part separately, of course, taking the appropriate number of stages for each section.

We shall also assume, for simplicity of calculation, that the stage heat drops are so allocated that the useful heat, *i.e.*, stage heat drop multiplied by stage efficiency, is the same for each stage. In practice, the useful heat usually increases from one stage to the next; but the error arising from too close spacing of the stages on the chart at the exhaust end will be partly counteracted by the effect of too wide spacing at the inlet end, so that the total error is very slight.

The derivation of the formula which we shall finally obtain takes place by a series of approximations. We shall first assume that the isobars are straight over the short distances considered, and later make a correction for the error involved in this assumption. We shall also assume that the temperature falls uniformly along the expansion line. A glance at the heat chart will show that in the superheat region, to which we shall confine our attention at first, this is not far from the truth. Later, a closer approximation will be made. Thus, referring to Fig. 1, we shall assume that the temperature at a point such as X is given by the expression $a+b\,x$, where x is the difference between the initial total heat and the total heat at X; a and b are constants which are determined by the values of the initial and final temperatures and other data, as will be shown later.

The following notation will be used:—

T_o = initial temperature in degrees Fahrenheit absolute
T_n = final temperature in degrees Fahrenheit absolute.
T'_n = temperature in degrees Fahrenheit absolute at the end point of the adiabatic expansion.
n = number of stages.
η = internal efficiency ratio.
$l = 1-\eta$ = fractional internal loss.
R_n = reheat factor for n stages.
$\rho_n = R_n - 1$ = reheat fraction for n stages.
H = adiabatic heat drop, B.Th.U. per lb.
$h_r = r^{th}$ stage heat drop, B.Th.U. per lb.

On the foregoing hypotheses, the useful heat in each stage is $\eta H/n$, and the temperature at the end of the r^{th} stage is

$$a + b\,r\,\frac{\eta H}{n}$$

Referring now to Fig. 2, which represents the triangle for the r^{th} stage drawn to a large scale, h_r is the stage heat drop and the angle λ is constant for all stages. From simple geometry, it is clear that

$$\frac{\eta H}{n}\tan\lambda = \left(h_r - \frac{\eta H}{n}\right)\tan\theta$$

$$\therefore\ h_r = \frac{\eta H}{n}\left(1 + \frac{\tan\lambda}{\tan\theta}\right)$$

Now, since the temperature at the end of the stage is $a+b\,r\,\frac{\eta H}{n}$, and the isobar is nearly straight over the short length B C, then approximately

$$\tan\theta = \frac{1000}{a + b\,r\,\frac{\eta H}{n}}$$

Introducing this, we have

$$h_r = \frac{\eta H}{n}\left[1 + \frac{\tan\lambda}{1000}\left(a + b\,r\,\frac{\eta H}{n}\right)\right]$$

Summing the stage heat drops for all of the n stages, we find

$$\sum_{r=1}^{n} h_r = \eta H\left[1 + \frac{\tan\lambda}{1000}\cdot\frac{1}{n}\sum_{r=1}^{n}\left(a + b\,r\,\frac{\eta H}{n}\right)\right]$$

$$= \eta H\left[1 + \frac{\tan\lambda}{1000}\left(a + b\,\eta H\,\frac{n(n+1)}{2n^2}\right)\right]$$

It is now necessary to introduce the value of the constants a and b. We have

$$\left.\begin{aligned} \text{When } x=0,\quad & a + b\,x = T_o \\ x=\eta H,\quad & a + b\,x = T_n \end{aligned}\right)$$

These relations give

$$\left.\begin{aligned} a &= T_o \\ b &= -\frac{T_o - T_n}{\eta H} \end{aligned}\right)$$

Substituting these values, and noticing that

$$\tan\lambda = \frac{D}{\eta_1 H}$$

where D is a length scaled from the heat chart, as shown in Fig. 1, we obtain

$$R_n H = \sum_{r=1}^{n} h_r = \eta H + \frac{D}{2000}\left[\frac{n-1}{n}T_o + \frac{n+1}{n}T_n\right]$$

or

$$R_n = \eta + \frac{D}{2H}\left[\frac{n-1}{n}T_o + \frac{n'+1}{n}T_n\right]\frac{1}{1000} \quad . \quad . \quad (1)$$

This is a first approximation to the value of the reheat factor R_n. Let us next examine the error which arises from the assumption of linear fall of temperature. If this fall is not linear, but instead obeys a square law, then the simple form $a+b\,x$ employed above must be replaced by an expression of the form $a+b\,x+c\,x^2$. If this is done, and the work carried on in a similar way to that outlined in the preceding paragraph, we shall find, after slightly more involved calculation, the relation

$$R_n = \eta + \frac{D}{6H}\left[\frac{(n-1)(n-2)}{n^2}T_o + 4\,\frac{n^2-1}{n^2}T' + \frac{(n+1)(n+2)}{n^2}T_n\right]\frac{1}{1000} \quad . \quad . \quad . \quad (2)$$

where T′ is the absolute temperature at the middle point of the expansion line.

One or two actual examples on the heat chart will show that the values given by (1) and (2) only differ by a very small amount, of the order of 0·1 per cent., thus showing that the assumption of linear fall of temperature is sufficiently accurate for the present purpose. Equation (2) will consequently be discarded as being an unnecessary complication.

A correction is now required by the fact that the isobars are not straight, but slightly curved. Referring

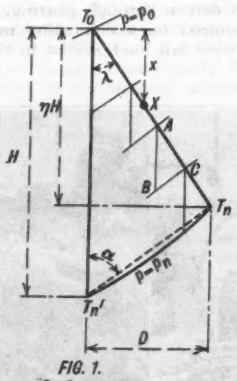


FIG. 1.
"The Engineer"

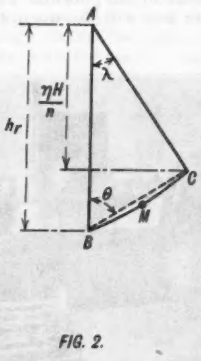


FIG. 2.

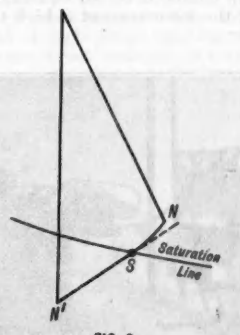


FIG. 3.

again to Fig. 2, the slope of the straight line B C has been taken as that of the isobar at C. A more accurate value will be obtained by taking instead the slope of the same isobar at M, the mid-point of the curve B C, since the tangent at M will be very nearly parallel to the straight line B C. A few moments' consideration will show that this is equivalent to reducing all temperatures along the expansion line by the amount

$$\frac{1}{2}\,\frac{T_n-T'_n}{n}$$

since the linear fall of temperature has been shown to hold with little error.

With this correction equation (1) becomes

$$R_n=\eta+\frac{D}{2H}\left[\frac{n-1}{n}\,T_o{}^*+\frac{n+1}{n}\,T_n{}^*\right]\frac{1}{1000}$$

where

$$T_o-T_o{}^*=T_n-T_n{}^*=\frac{1}{2}\,\frac{T_n-T'_n}{n}$$

The same correction must be applied to each of the temperatures involved in equation (2) if the latter is used. The magnitude of the correction is usually less than 0·5 per cent. in R_n.

In all the foregoing calculations the value of D requires to be scaled from the heat chart. This may be avoided by writing

$$D=(1-\eta)\,H\tan\alpha=l\,H\tan\alpha,$$

where α is as shown in Fig. 1. Clearly, tan α is very nearly equal to the slope of the isobar at a temperature midway between T_n and T'_n, namely

$$\tan\alpha=\frac{1000}{\frac{1}{2}\,(T_n+T'_n)}$$

Introducing this fact, and remembering the correction necessary to give $T_o{}^*$ and $T_n{}^*$, we obtain

$$R_n=\eta+\frac{1-\eta}{2}\times\frac{2000}{T_n+T'_n}\left[\frac{n-1}{n}\,T_o+\frac{n+1}{n}\,T_n-2\,\frac{T_n-T'_n}{2n}\right]\frac{1}{1000}$$

$$=\eta+\frac{1-\eta}{T_n+T'_n}\left[T_o+T_n-\frac{T_o-T'_n}{n}\right]$$

or

$$\rho\,n=l\left[\frac{T_o+T_n-\frac{T_o-T'_n}{n}}{T_n+T'_n}-1\right]$$

where ρ_n is the fractional reheat and l the fractional internal loss.

This reduces to the elegant form

$$\rho_n=l\times\frac{T_o-T'_n}{T_n+T'_n}\times\frac{n-1}{n}\quad\ldots\quad(4)$$

The value for an infinite number of stages is, of course, given by writing $\frac{n-1}{n}=1$; hence

$$\rho\,\infty=l\,\frac{T_o-T'_n}{T_n+T'_n}$$

It will be remembered that equation (4) has been derived for the superheat region only. For the wet region, the temperatures to be taken are the saturation temperatures at the pressures under consideration. Here, again, it has been found, by comparing calculations made with formulæ (1) and (2), that in this region also the fall of temperature along a straight expansion line is very nearly linear, though the rate of fall is less than in the superheat region. Consequently, equation (4) also holds for the wet region, and, in fact, the calculation is simplified, because $T_n=T'_n$. But it is essential to note that it is not permissible to continue a single calculation from one region to the other. If the expansion line crosses the saturation line, then the parts lying in the two regions must be treated separately, employing appropriate values of n for each region and applying each of the two values of ρ_n to the appropriate heat drop scaled from the chart; the values of η will, of course, differ in the two regions, and must be measured from the chart. The overall reheat factor is then $\frac{H_1R_1+H_2R_2}{H}$, the notation being self-explanatory.

In his book "Steam Turbines" (second edition, 1929, page 578) Goudie gives an approximate formula for reheat for an infinite number of stages for saturated steam, deduced by him from a more accurate relation due to Callendar. By changing the variables and rearranging the formula may be written

$$\rho=(1-\eta)\,\frac{T_o-T_n}{2\,T_n}\times C,$$

where C is a constant less than unity, and which, according to Goudie, may be taken as 0·86 for the average case occurring in practice. Since $T_n=T'_n$ in the wet region, this formula may be obtained from equation (4); though the constant C will be slightly less than $\frac{n-1}{n}$, as Goudie's formula is based on a constant stage efficiency which gives slightly less reheat than a straight expansion line, other things being equal. If we may take eight stages as an average value for normal practice, then $\frac{n-1}{n}=0\cdot875$, and the value of 0·86 in Goudie's formula thus corresponds to about eight stages.

There is one case which may appear at first sight to give trouble, namely, where the saturation line runs between the points marked N and N^1 in Fig. 3. In this case no great inaccuracy will as a rule be incurred by using equation (4) as it stands. If even this inaccuracy is to be avoided, then an exact calculation may, of course, be made by treating the parts, N^1S and S N, of the isobar separately; but a quite sufficient approximation will be obtained by the following procedure. Calculate two values of ρ_n from equation (4), one by employing $T_n+T'_n$ in the denominator of the right-hand side of the equation, and the other employing $2\,T'_n$ in the denominator. Then interpolate between these two values in the ratio in which N N^1 is divided by the point S, a mental estimate of this ratio being quite sufficient, as the two values of ρ_n will only differ very slightly.

Equation (4) has thus been found to hold in both wet and superheat regions, with the proviso that the saturation line must not be crossed in one operation, and with the slight modification required to deal with a special case, which sometimes occurs, mentioned in the previous paragraph. From the form of the equation, the reheat fraction is seen to be proportional to $\frac{n-1}{n}$, and approximately proportional to the fractional internal loss. It has long been observed that these proportionalities were *approximately* true, but so far as can be ascertained the more exact relationship of equation (4) has not previously been traced. Note that having calculated the reheat fraction for one value of η, then if η is varied slightly the new reheat may be taken as proportional to $1-\eta$, since the variation in T_n for a slight change in η is very small.

The foregoing results have proved of value in several ways. A rapid method of calculating the reheat fraction is of great assistance in the preliminary design of a turbine, or, as noted in the previous paragraph, in correcting calculations which have been made on an incorrect expansion line. Furthermore, small inaccuracies are unavoidable in the drawing and reproduction of the heat chart, or in its use to calculate reheat by actually drawing down and scaling the individual heat drops. A very small error in the position of the isobars may result in a large error in the measurement of reheat. This is particularly the case in the region of high pressures, where the reheat is so small that it is very difficult to measure accurately; in fact, measurements of an apparent *negative* reheat are not unknown. Calculation by equation (4) gives consistent results which are in excellent agreement with the mean of many actual measurements up to a pressure of 1800 lb. per square inch, the highest so far examined.

From the considerations in the previous paragraph, it is clear that it is difficult to check the accuracy of formula (4) by actual measurements of a number of examples, since these actual measurements are so undependable, and vary so much when made by different individuals. The probable accuracy of the formula, when the assumptions of straight expansion line and equal distribution of useful heat are adhered to, is about 1 per cent. in the reheat fraction. However, taking a conservative estimate to allow for variations from these assumptions, it is safe to assert, and is fully borne out by the mean of many measurements, that the error in the reheat factor is not more than one-quarter of 1 per cent.

Finally, the following rough approximation to the reheat fraction has been found empirically by examining a large number of cases by equation (4). Approximate reheat percentage

$$=K\times\frac{\text{percentage internal losses}}{30}\times\left(\frac{H}{100}\right)^{1\cdot25}\times\frac{n-1}{n}$$

where H is the adiabatic heat drop in B.Th.U. per lb. and K is a constant having the value 3·5 in the superheat region and 1·4 in the wet region. The exponent 1·25 is taken for ease of computation on a slide rule though probably 1·2 is a more accurate figure. The reheat factor calculated from this equation is probably accurate to within ½ to 1 per cent., so that it is much inferior to equation (4). It is occasionally convenient for obtaining a rough estimate rapidly. Here again the saturation line must not be crossed in one operation.

In conclusion, the writer wishes to thank the English Electric Company, Ltd., for permission to make use of a number of actual turbine calculations, which have afforded a practical test of the accuracy and range of usefulness of the theoretical results described in this article.

The New Orient Line Steamer "Orion."

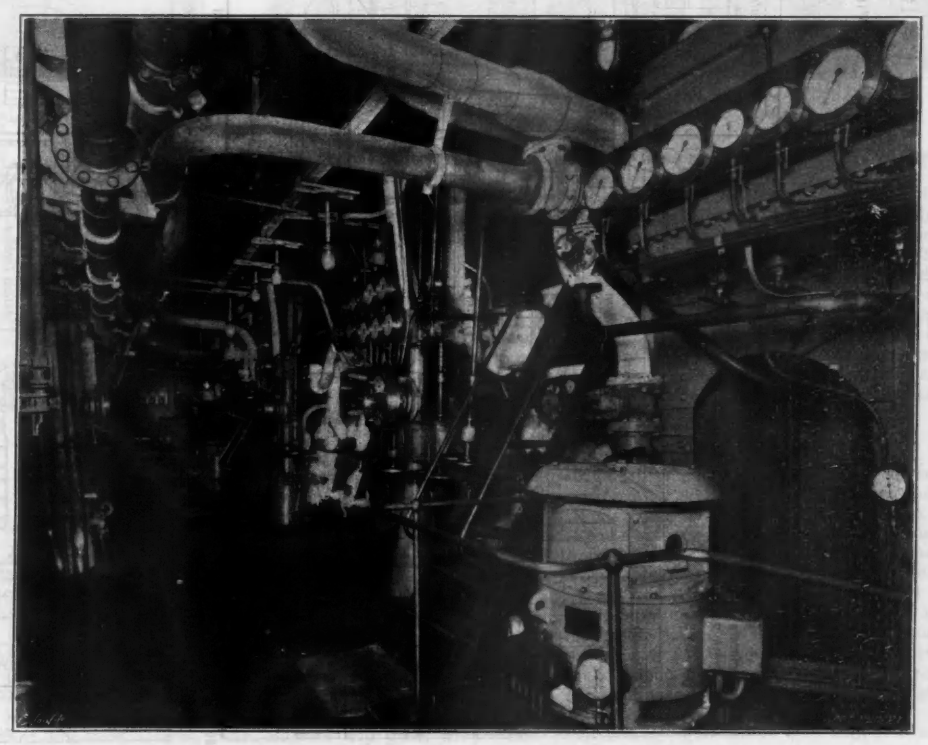
No. II.

(*Concluded from page 199, August 23rd*).

IN our previous article we dealt principally with the hull of the ship and her passenger accommodation and mentioned some of her outstanding features and her auxiliary machinery. We now pass to the main propelling machinery, generator sets, and refrigerating equipment. The principal particulars of the plant are given in the table on page 215.

Turbine Arrangement.

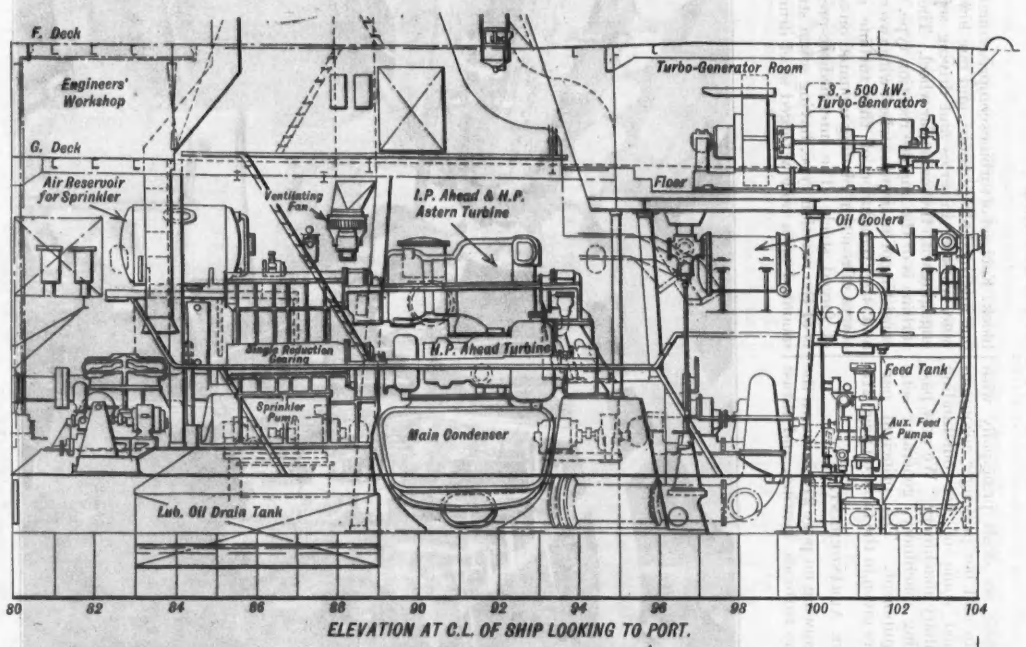
To the left of the drawing on page 214 is shown the general lay-out of the turbines, gearing, and thrust block. Each set of turbines comprises one high-pressure, one intermediate-pressure, and one low-pressure turbine, working in series and driving separate pinions engaging with the main gear wheel. The high-pressure turbine is of the impulse reaction type, the first stage consisting of an impulse wheel with two rows of blades, and the remainder of this turbine comprises six stages of reaction blading mounted on a hollow drum of forged steel. The intermediate-pressure turbine is of the reaction type, having seven stages of blades mounted on a hollow forged steel drum; while the



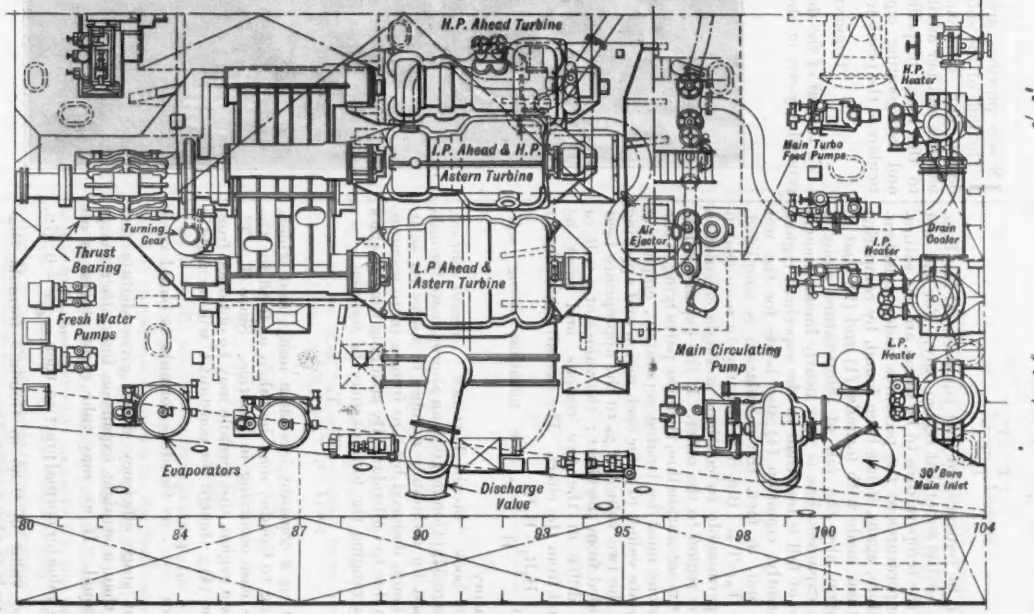
MAIN CONTROL PLATFORM

ENGINE AND BOILER-ROOM ARRANGEMENT OF THE ORIENT LINER "ORION"

VICKERS - ARMSTRONGS, LTD., BARROW - IN - FURNESS, BUILDERS

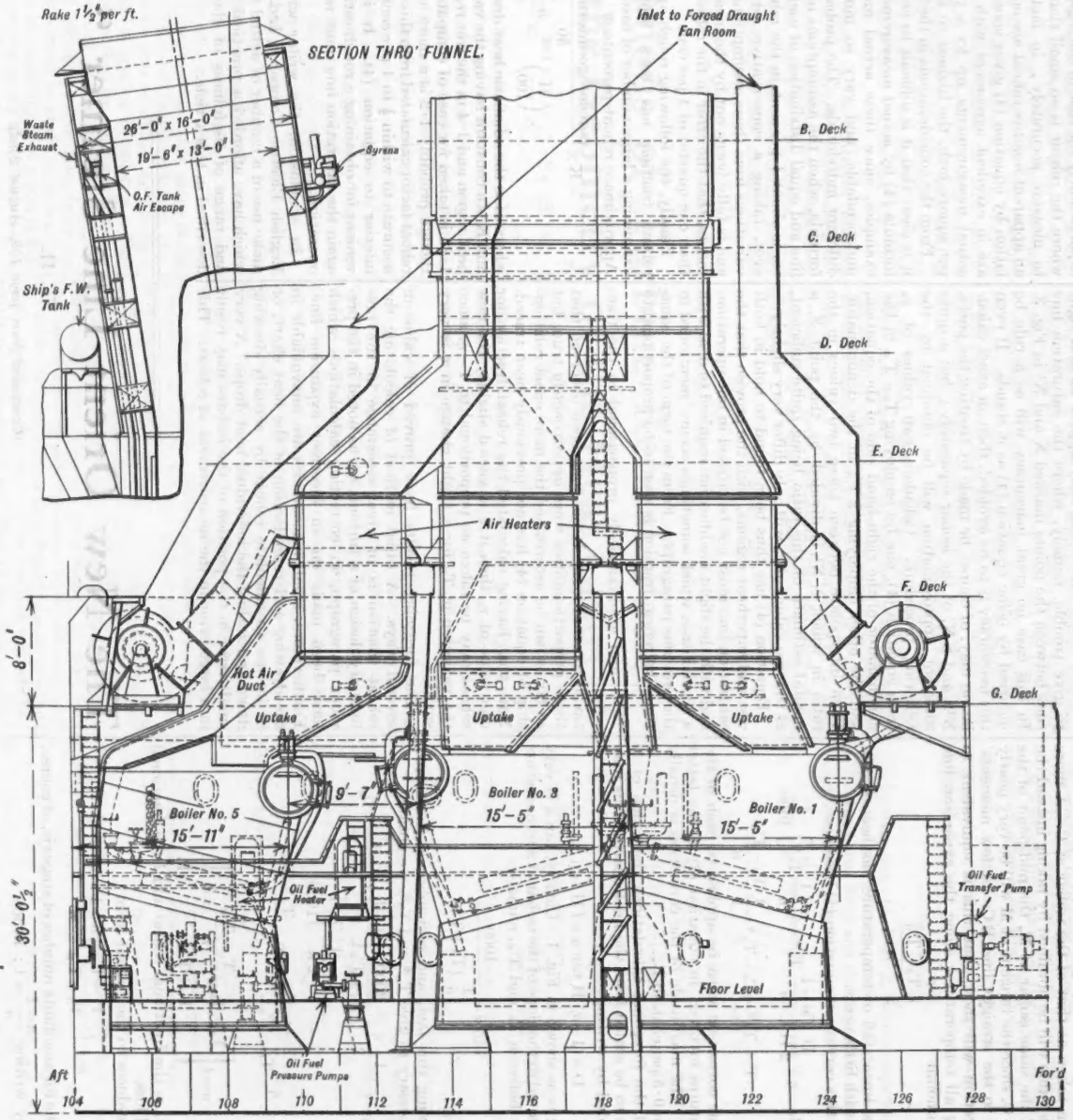


ELEVATION AT C.L. OF SHIP LOOKING TO PORT.



"The Engineer"

HALF PLAN OF ENGINE ROOM.



SECTIONAL ELEVATION OF BOILER ROOMS LOOKING TO PORT.

low-pressure turbine is of the single-flow type, with sixteen rows of reaction blading mounted on forged steel disc wheels.

Propelling Machinery.

Type: Twin-screw, single-reduction Parsons geared turbines	
Designed service output	24,000 s.h.p.
Astern power	70 per cent. of ahead power
Turbine speed	1,715 r.p.m.
Propeller speed	112 r.p.m.

Boiler Installation.

Type of boilers	Babcock and Wilcox oil-fired
Number of boilers	Four large, two small
Designed steam output	240,000 lb. per hour
Working pressure	425 lb. per square inch
Safety valve blow-off pressure	450 lb. per square inch
Total superheated steam temperature	725 deg. Fah.
Total heating surface	37,030 square feet
Total superheater surface	5,714 square feet
Total air heater surface	40,000 square feet
Guaranteed overall boiler efficiency	86 per cent.

Turbo-generator Sets.

Number of sets	Three
Total designed output	1,500 kW
Turbine speed	5,000 r.p.m.
Generator speed	500 r.p.m.
Voltage	220 volts

Emergency Generator Set.

One 90-kW Allen oil engine driven set

The astern turbines are two in number, on each set there being one high-pressure and one low-pressure turbine working in series. The H.P. astern turbine is incorporated in the intermediate cylinder, and consists of one three-row impulse wheel, while the low-pressure astern turbine is incorporated in the low-pressure casing. It is composed of one two-stage impulse wheel, followed by five stages of reaction blading.

The rotor shafts of all the turbines are finished with both labyrinth and carbon packings, and Michell pattern pivoted adjusting blocks are fitted to the turbines. All the turbines are designed to run at 1715 r.p.m., while the gear ratio is such that at this turbine speed the propellers run at 112 revolutions. The propellers, it may be stated, are of the four-bladed built-up type, with cast steel bosses, and manganese bronze blades. They were designed and supplied by J. Stone and Co., Ltd., of Deptford. There are eight working blades and four spares. Each blade weighs about 3½ tons, and has a length of 8ft. from the tip to the flange. The diameter of the built-up propeller is 19ft. During the official trials of the liner over 24,000 s.h.p. was developed at normal speed, and the power developed astern was shown to be over 70 per cent. of the ahead power. A feature of the machinery is its very smooth running with absence of vibration, alike at full and cruising speeds, along with a high fuel economy.

As the drawings on page 214 show in general outline, the turbines are connected by flexible couplings to nickel steel pinions, which engage with the main wheels on the propeller shafts. The gearing is of the double-helical, single-reduction type, having Vickers-Bostock-Bramley patented "enveloping" gear teeth. Each gear wheel consists of a cast iron centre with a forged steel rim shrunk on, and central bearings are fitted to the pinion shafts. The shaft bearings for both turbines and gearing are supplied with forced lubrication, and the thrust blocks, which are of Michell type, are placed on the shafts close up to the gearing. On each oil connection to the pinion and bearings there is a rotating indicator of the Hawthorn Leslie type.

The main condensers are of the Weir "Regenerative" pattern, suspended from the low-pressure turbine casings, with spring supports to relieve the load on the turbines. The total cooling surface in the condensers is 25,000 square feet, and is designed to maintain a vacuum of 28in. of mercury with the barometer at 30in., and a sea water temperature of 86 deg. Fah. The air injectors, auxiliary air pumps, and boiler feed pumps, also the extraction pumps and evaporators, are of the latest Weir type, working on the closed feed principle. On page 213 we illustrate the main control platform, with the convenient grouping of all instruments. These include Crockatt salinometers and Kent steam meters.

Boiler Installation.

Below we reproduce a view of the forward boiler-room. The steam-generating installation consists of six Babcock and Wilcox high-pressure marine boilers, which were built at Barrow. There are four large boilers and two small boilers, both fitted with superheaters and tubular air heaters. The boilers are constructed for a safety valve blow-off pressure of 450 lb. per square inch, the steam being superheated to 725 deg. Fah. The working pressure for the main turbines is 425 lb., and 400 lb. for the auxiliary generator sets.

The total generating surface of the four large boilers is 29,860 square feet, with a total superheating surface of 7440 square feet, the total generating surface of the two small boilers being 7170 square feet, with a total superheater surface of 2140 square feet. The air heating surfaces for the large and small boilers are 32,000 square feet and 8000 square feet respectively.

The boilers are arranged to burn oil only under the forced-draught, closed air duct system, with open stokeholds, air being supplied to the boilers by five double-inlet electrically driven fans of Howden design.

The Wallsend oil fuel installation consists of four units, each comprising one electrically driven pump and one heater, one pair working and one pair standby. There are six burners for each of the large boilers and four for the small boilers.

There are two Carruthers oil fuel transfer pumps of the electrically driven two-throw type, each having a capacity of 60 tons per hour for transferring oil to the settling tanks. Diamond soot blowers are provided for both the boilers and the air heaters. Mumford low-level alarms, with oil fuel trip gear, are fitted to all boilers. On page 214 we show one of the funnel uptakes and the inside arrangement of exhaust pipes.

Some Auxiliaries.

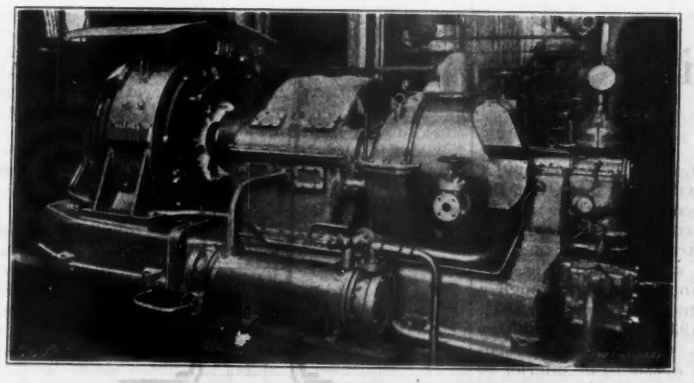
The main generating sets, one of which is shown on this page, comprise three Allen turbo-generators, each set consisting of a steam turbine driving a dynamo through double helical gears. Each machine is designed to give a full load output of 500 kW, with an overload of 25 per cent. for two hours. The turbines run at a speed of 5000 r.p.m., and work at a steam pressure of 400 lb. at a temperature of 725 deg. Fah. They are arranged to exhaust into a heater when at sea and into an auxiliary condenser when in port. Provision is made for a suitable quantity of steam to be bled, if necessary, from these turbines, in order to heat the condensate. The dynamos, which run at 500 r.p.m., are compound wound and generate at 220 volts with a maximum temperature rise of 55 deg. Fah., after a six hours' full load run. In a deck compartment forward there is an emergency generator, consisting of an Allen six-cylinder vertical airless-injection four-stroke cycle oil engine, running at a speed of 500 r.p.m. directly coupled to a 220-volt compound-wound dynamo. The set has a normal rating of 90 kW, with an overload of 10 per cent. for one hour. It has self-contained cooling water arrangements, comprising a radiator, air cooled by a fan mounted on an extension of the dynamo shaft, and a circulating pump driven direct from the engine. Instant starting from cold is effected by means of compressed air and a separate Lister auxiliary oil engine driven air compressor is provided for charging the air bottles.

Other interesting auxiliaries include the Allen main circulating pumps, which are two in number, each consisting of a steam turbine driving a horizontal pump through speed-reducing gear. The turbines are rated at 130 b.h.p., and run at a speed of 4250 r.p.m. The pumps have 30in. branches and are each designed to deliver 16,000 gallons of water per minute to the main condensers when running at 425 r.p.m. A view of one of these pumps in the maker's works is reproduced herewith. W. H. Allen, Sons and Co., Ltd., also supplied a large number of other pumps and driving motors.

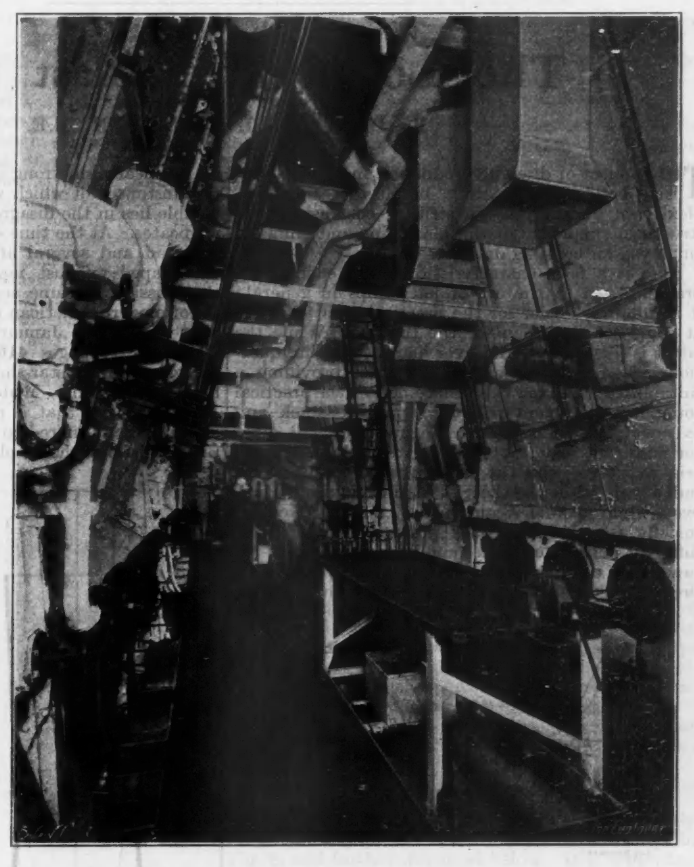
Refrigerating Equipment.

The refrigerating equipment in the "Orion" marks an interesting advance, as, apart from cargo and provision rooms, she is the first British ship on this service to be equipped with air-conditioning plant for the dining saloon. The refrigerated cargo space consists of Nos. 1, 2, and 3 holds and 'tween decks, while the main provision chambers are situated on "J" deck immediately abaft the cargo spaces, the total capacity of the cargo and provision rooms being approximately 244,000 cubic feet. In addition to the main provision chambers, a series of cold cupboards on the galley deck and milk-cooling machines are cooled by brine from the main service.

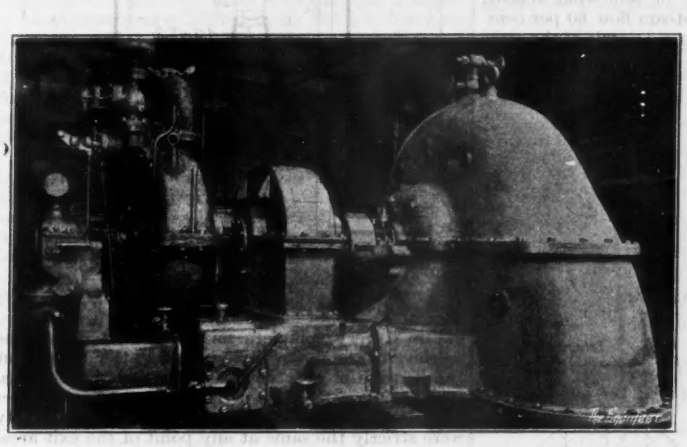
The refrigerating machinery was supplied and fitted by J. and E. Hall, Ltd., and is arranged in a



500 KW. TURBO-GENERATOR SET



FORWARD BOILER-ROOM



TURBINE-DRIVEN CIRCULATING PUMP

room on the tank top forward of the boiler rooms. It comprises four of the latest type of electrically driven horizontal twin CO_2 machines. Under normal conditions two of the machines will deal with the insulated cargo and provision room duty, and one with the air conditioning, the fourth machine being a standby for either duty. The No. 1 lower hold and 'tween deck is intended mainly for the carriage of frozen produce, and is fitted with brine grids on the overhead and sides, while Nos. 2 and 3 hold and 'tween decks are equipped in addition with brine batteries and fans for cool air circulation, the spaces being adapted for the carriage of frozen meat and/or fruit. In accordance with the latest practice, the 'tween decks are made gas-tight, so that CO_2 injection may be used when chilled meat is being carried. No. 3 'tween deck is subdivided into four separate chambers, each being available for frozen meat, chilled beef, or fruit.

A number of "Hallmark" methyl chloride compressors with automatic control have also been supplied.

Sewage Disposal Arrangements.

The sewage disposal apparatus in the ship was designed and supplied by Adams-Hydraulics, Ltd., York. It consists of five Amphistoma centrifugal pumps automatically controlled. They are of the vertical-spindle pattern, each driven by an electric motor mounted directly on the pump top. The sewage first enters a small steel collecting tank, and when a predetermined level is attained, the motor is started by means of a float switch, and the pump discharges the contents of the tank below the water line.

There are three sewage collecting tanks in all. Two of them are connected to duplicate pumps, the third being connected to a single pump, which is cross-connected to one of the other units. Each pump deals with 150 gallons of sewage per minute against 50ft. head. Automatic float operated alarm gear is fitted to each tank to give audible warning in case of failure of the pumps to keep the level of sewage below a predetermined point.

Conclusion.

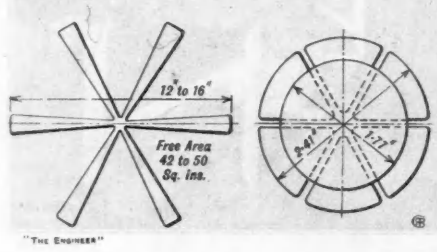
In the short description given above it has not been possible to refer in detail to all the equipment which forms part of this very fine ship. In the co-ordinating of the various parts to form a complete whole, much has been done by Mr. J. Peacock, the owner's superintendent engineer, and Mr. F. Walker, the company's naval architect, who have worked closely with the technical staff of Vickers-Armstrongs, Ltd., and with Mr. Brian O'Rorke, who was entrusted with the ship's decoration. In conclusion, it may also be stated that most of the large steel forgings, including the seamless steel boiler drums, the propeller shafting, turbine rotors, gear wheel rims, and pinions, were manufactured by the English Steel Corporation, at Vickers Works, Sheffield, which firm also supplied the stainless steel turbine blading and nozzle vane material.

The Locomotive Blast Pipe.

By Dr. A. GIESL-GIESLINGEN, M.E.

THE subject of draught production in the locomotive boiler is fascinating, because of the complexity of its analysis—in striking contrast to the structural simplicity of the blast pipe and chimney employed for creating draught.

Here is a fact, characteristic to this engineering problem, and to the art of jet pumps in general: it is infinitely easier for the practical man to arrive at some solution than for the theorist. While the latter is likely to ponder over many confusing questions when charged with the task of providing a suitable front end for a given locomotive, the practical roundhouse foreman will take a smoke-stack and exhaust pipe from another engine, and will quite certainly succeed in "making steam" after some trial and error with the exhaust nozzle, and he will pull a train while the theorist is still thinking. However, while making steam is easy, making it economically and with low back pressure is an entirely different matter to the accomplishment of which the practice of copying chimney and exhaust pipe from a predecessor is not conducive. Up to the present,

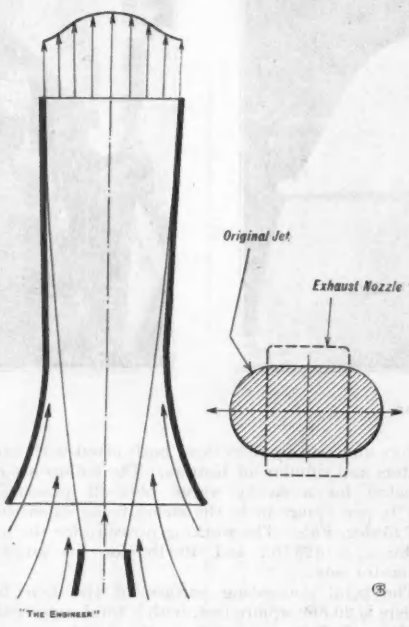


FIGS. 1 AND 2

though, that practice is still universal because the theorists have apparently failed to satisfy the requirements of the designer.

On the other hand, a century of empirics, including some investigations on a very broad basis, has clearly demonstrated that science is indispensable to a satisfactory solution of the blast pipe problem. The virtual confusion which exists as to the optimum design of blast pipe and chimney can never be cleared by empirics alone. Needless to say, the theory will fully respect established experience—only pseudo-science scoffs at the practical man. But in order to succeed, the scientist must firmly rely upon his own judgment; he must have the courage of making his own deductions from established laws of thermodynamics and physics and from his scientific intuition, and if on this basis he has to contradict an allegation based upon empirics, he will do well to be uncompromising.

An example for the urgent need of such an attitude is offered by the "fancy blast pipes." Britons, due to their more sober realism, have contributed less to this questionable art than others who were more ready to believe in mysteries. The records of the U.S. Patent Office, to which inventors all over the world confided their hopes, provide a fertile searching ground, and the late W. E. Symons, once editor of the now extinct *Railway and Locomotive Engineering*, very rightly said that a display of exhaust nozzles would be fitting to a curiosity shop rather than to an exhibition of mechanical skill. The fancy shapes are by no means all wrong; a few are beneficial under circumstances of which we will speak later, but the trouble lies in the disagreement among their various advocates. At the time of writing, the Pennsylvania Railroad and several affiliated lines are using the star-shaped exhaust nozzle as standard (Fig. 1); the Russians became acquainted with it through a set of modern American locomotives ordered in 1931. However, in the January, 1935, issue, the *Railway Engineer*, on pages 416–18, reports that Russian tests showed the star-shaped nozzle to be inferior to a plain round one. Model tests by the University of Illinois[1] reveal that a nozzle of somewhat related shape (Fig. 2) offered to the steam flow 60 per cent. more resistance than a plain round nozzle of the same



FIGS. 3 AND 4

free area; exactly the same figure follows from test results published in *Railway Age* of 1933, pages 84–85, wherein a well-developed star-shaped nozzle created a back pressure of 16 lb. per square inch, and more when the engine was working near capacity, while only 10 lb. would have been expected from the apparent free area of 53·1 square inches. Yet the last-mentioned article proves also that the star-shaped nozzle was a very big improvement upon the plain round nozzle and chimney arrangement originally used on these engines. Unanswered remains the question whether another plain round nozzle and chimney could be found to excel over both of them.

Another significant instance of confusion is illustrated by the above-mentioned Russian tests, as reported by the *Railway Engineer*. A rectangular nozzle of 4⅛in. by 6⅞in., when substituted for a round nozzle of 5⅛in. diameter, allegedly delivered the same smoke-box draught of 5·9in. of water with exactly half the back pressure, *e.g.*, 2·95 lb. Its performance topped by a considerable margin even that of a Kylala blast pipe, now so favoured in France with Monsieur Chapelon's refinements. Rectangular blast nozzles of the variable kind have been widely used in Continental Europe,[2] particularly also in my native Austria. Some were very efficient, such as that of the old 4–4–0 type express locomotive, Series 17c of the Austrian Southern Railway (Fig. 5), and others rather poor, such as that of the newer 4–6–0 express locomotive, Series 109 of the same road. In many cases the variable nozzle lost favour, and was replaced by a fixed circular one without apparent loss in efficiency. In recent years, the Franklin Railway Supply Company has sponsored rectangular nozzles,[3] but none has survived to this day in the United States. All this would hardly be possible if the favourable effect found in the Russian tests was actually inherent to the rectangular nozzle in general.

Now let us regard the case of the rectangular nozzle from the scientific side. We have a chimney of circular cross section and we are sending a steam jet up that chimney with the intent of entraining the smoke-box gases, of slightly compressing the mixture of steam and gas from the smoke-box pressure to that of the outer atmosphere, and of expelling said mixture from the chimney. One observation we may borrow from experience. If the chimney is long enough and if its exit is so situated that gas and steam have ample time to intermingle, as indicated in Fig. 3, then we

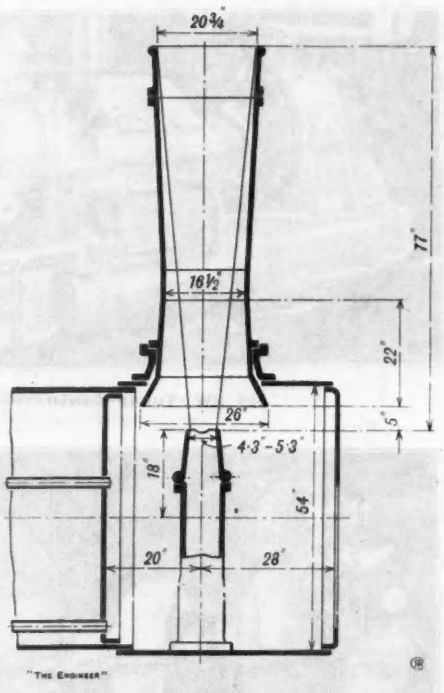


FIG. 5

obtain a very complete mixture at the top. The velocity of the flow will be higher in the centre, but the distribution over the area will be such that the total kinetic energy is only perhaps 10 per cent. higher than it would be if the arithmetic average velocity were strictly the same at any point of the exit area. Ample proof of this is contained in Dr. F. C. Huygen's fine investigation of the subject.[4] We may further reason that the kinetic energy remaining and practically lost in the mixture at the chimney exit will be a minimum if the flow is as homogeneous as possible. The process of converting velocity into pressure will also be most efficient if undisturbed by irregular cross-currents; in other words, if there is radial symmetry in the flow relative to the central axis of the circular chimney at any level from the exhaust nozzle up to the chimney exit. These requirements follow with certainty from our conception of fluid mechanics; why, then, should there be any advantage in having an unsymmetric distribution of steam in the flow through a circular chimney, as would be the case if the steam jet were of rectangular cross section? It is inconceivable that there be any advantage, and our conception is well enough founded to say that it is impossible. Having come to this conclusion, we can deduct further that, if it be granted that the rectangular exhaust nozzle used in the Russian test gave the improvement claimed, then the jet from the exhaust pipe must have had an original tendency to depart from the optimal circular cross section. It probably tended to spread in a certain diagonal direction as shown in Fig. 4, and by forcing

[1] "A Study of the Locomotive Front End," Bulletin No. 256 of May 30th, 1933, especially on pages 67, 91, 92, and 165.

[2] *Journal* of the Inst. of Locomotive Engineers, 1933, page 179.

[3] "Locomotive Cyclopedia of American Practice," 1930, ninth edition, page 386; and *Journal* of the Inst. of Locomotive Engineers, 1932, page 305.

[4] Summary reported by A. Giesl-Gieslingen, in *Zeitschrift des Oesterr. Ingenieur- und Architekten-Vereines*, Vienna, 1924, page 248.

it through an exhaust nozzle which restrained this tendency while favouring the spread in a direction transverse thereto, as indicated in dotted lines, the final jet filled the chimney more uniformly than if its tendency to be oval had not been thus counteracted. A glance at Fig. 6 on page 417 of the discussed article in the *Railway Engineer* confirms, in fact, that the rather unhappy design of the exhaust pipes just below the nozzle distinctly tended to contract the steam jet transversely to the locomotive, and by placing the longer axis of the exhaust opening in this direction the steam jet was treated according to our reasoning above. There is no mystery in the phenomenon; the rectangular nozzle proved to be helpful merely because it partially corrected a faulty special condition.

We can further extend our reasoning. The result obtained by the said correction having been so striking, we must conclude that the original transverse contraction of the jet must have been so pronounced that it failed to fill the chimney along the sides; even with the correction applied, the chimney was probably only filled on a very short length near its top, and gas and steam failed to have a chance to mix thoroughly. Therefore, after the steam was forced to spread still more by the use of a cruciform nozzle, a slight further improvement was obtained. But even then the back pressure was still 20 per cent. higher than for the old Austrian express locomotive, Series 17c, under comparable conditions, indicating that the final improvement meant only a relative, not an absolute record.

The above examples have been discussed at such length in order to show that simple scientific reasoning can do much to clear up many a blast pipe phenomenon. We are far too easily inclined to accept experiences with blast pipes and chimneys without subjecting them to the critical scrutiny which we would apply to almost any other field. We shall go a very long way toward solving our front end problems if we steadfastly refuse to believe in mysteries. For this reason we must not take for granted all that the practical man tells us about the blast pipe.

As stated hereinbefore, a satisfactory mixture between gas and steam may be obtained with a plain nozzle and a chimney of moderate and quite conventional length, for which Fig. 5 is a representative example. In such a blast pipe arrangement, the steam jet develops freely without being subjected to any coercion. It is a general law that coercion produces reaction; forcing a fluid to change its natural course inevitably produces resistance. It is easy to understand that the draught appliance which reaches the required quasi-homogeneous mixture at the chimney exit, while leaving the flow free from coercion, will be the most efficient, involving a minimum of energy losses. From this standpoint we shall prefer the simple arrangement of Fig. 5, or its combination with plain intermediate nozzles, which latter we cannot discuss within the space here available, although they have a wide field of usefulness.

However, let us assume that we have determined, by calculation, the most efficient outlet area and diameter D_o for the chimney of a given locomotive, and the exhaust nozzle diameter d_1 corresponding thereto. We know, then, from experience that the steam jet emerging from said blast pipe will not exceed a certain angular spread, and we can determine how great the distance or height a_o from the exhaust nozzle to the top of the chimney must be in order to safely fill the chimney outlet and to result in the desired adequate mixture of the escaping steam and gas. The process is illustrated by Fig. 6. Let us now

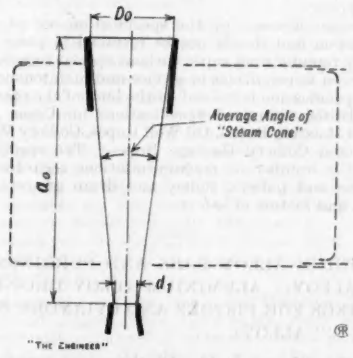


FIG. 6

assume that we have a rather large locomotive with a high boiler centre, and when trying to accommodate our draughting arrangement thus determined, we find—see the dotted lines in Fig. 6—that we have not enough space available, for we cannot place the exhaust nozzle under the bottom of the smoke-box. (Although in two-cylinder locomotives we may be able to depress the bottom as in some older British designs and in the Austrian 2–8–4 type, Series 214,[5] the exhaust nozzle of which is therefore situated 31in. below boiler centre.) If we cannot accommodate the optimal dimensions, then we have a great variety of choices; we may use a chimney of smaller diameter, but we cannot go very far in this direction without greatly increasing back pressure. Unless a small decrease of D_o (10 to 15 per cent.) is sufficient, the better way will be to artificially reduce the required height without reducing the outlet area, and to this end we have to choose between one of the "fancy blast pipes," special intermediate nozzles, double or multiple chimneys, chimneys of oblong cross section, or any combination of these, and then we enter a field relating to which we hear to-day the most amazing and contradictory stories.

Let it be sufficient to say at this time that even this complex problem can be disentangled. Now we shall determine the extent of that other region within which the plain round nozzle and chimney are supreme in efficiency.

An analysis of the front end in Fig. 5 showed that of the initial kinetic energy in the exhaust steam, somewhat more than one-third was used to do the

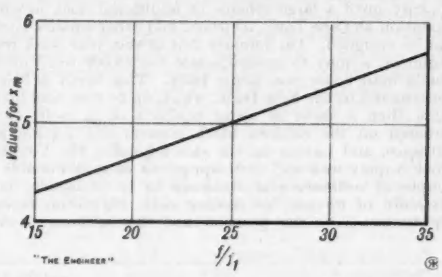


FIG. 7

work of pumping steam and gas from the smoke-box to the higher pressure of the outer atmosphere; somewhat less than one-third was lost in the form of kinetic energy in the mixture at the chimney exit, and one-third was lost through shock between the molecules of steam and gas during the process of entrainment and from other sources. This subdivision of the initial exhaust energy appears to be favourable in view of the good showing of this particular front end. Now we have to determine how conditions will be on other engines. In 1924 I published a short essay on the calculation of locomotive blast arrangements,[6] in which I suggested a way for convenient mathematical treatment of the subject. The main difficulty was at that time the determination of the shock loss. Meanwhile, I found this latter problem to be capable of very simple and surprisingly accurate solution. Generally speaking, the values for shock loss and exit loss in a chimney move

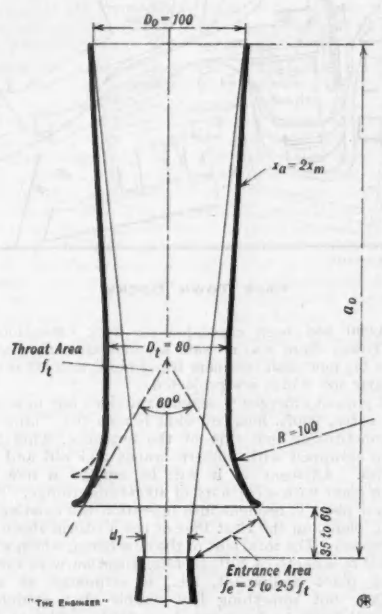


FIG. 8

in opposite directions if the width of the chimney is changed—a wider chimney means a smaller exit loss, but a higher shock loss, and *vice versâ*. Zeuner had found this already in 1860. Consequently there is an optimum width somewhere. The highly important result of the mathematical investigation is that in the optimum chimney arrangement the kinetic exit energy is equal to 65 per cent. of the pumping work. This figure is practically uninfluenced by the shape of the chimney, whether cylindrical or conical; the absolute efficiency or energy requirement is, however, best for certain conical chimneys.

The mathematical analysis shows further that, while the energy requirement for a given pumping work rises whenever we choose a chimney wider or narrower than the optimum, the rise is first very small, then increases progressively as we depart further from the said optimum dimension. Naturally, we shall never choose a chimney wider than the optimum, for we like to throw the exhaust into the air with whatever force we can reasonably obtain. Since we prefer therefore to be on the narrow side, it is reasonable to take advantage of the flatness of the energy curve near the optimum point. For instance, if we choose a chimney so much narrower that the exit energy amounts to 85 per cent. of the pumping work, we lose only 1·5 per cent. in efficiency; but from then on, the loss rises rather quickly. We may therefore define this latter relation as characterising the "practical optimum."

Simple mathematical operations, co-ordinated with tests of flow resistance through boilers and a normal grate and fire bed, lead to the following conclusions and formulæ:—First of all, we know already from experience that, if a front end delivers enough combustion air to burn the fire properly for a high rate of boiler output, then—provided that the blast arrangement be well proportioned—adequate draught will automatically be provided at all lower rates of boiler output. We need therefore merely make one calculation for approximately maximum boiler performance. Let us specify a gas flow of 12,000 lb. per square foot of free flue area, measured at the (Schmidt or similar type) superheater elements. We shall then find the smoke-box vacuum h for a boiler with an unobstructed, non-self-cleaning smoke-box.

$$(1) \quad . \quad . \quad h = \frac{0{\cdot}905}{100}\left[\frac{H_f + H_s}{f} + 100 + \frac{18{,}000}{(G/f)^2}\right]$$

in inches of water.

Wherein H_f = the fireside heating surface of all flues in square feet.
H_s = the fireside heating surface of the superheater in square feet.
f = the free flue area through the boiler barrel in square feet.
G = the grate area in square feet.

In this expression the first member depicts the frictional resistance in the boiler barrel, the second the exit loss at the front tube sheet, and the third the resistance in fire-box, fire-bed, grate and ash-pan. We need not worry about variations in the latter, since we have to decide on a certain chimney, and we might as well take one for average conditions. If the smoke-box is self-cleaning, a suitable addition must be given to the h thus obtained, amounting to 35–40 per cent. for the standard American Master Mechanics plate arrangement.

If we assume now that the fuel is burned with 45 per cent. of excess air, the weight relation between combustion gas and blast pipe steam will be about 2·5, no matter whether the locomotive has a feed-water heater or not. We obtain the following simple relation for the outlet area of the "best practical chimney" as above defined.

$$(2) \quad . \quad . \quad . \quad . \quad . \quad . \quad \frac{f_o}{f} = \frac{1{\cdot}56}{\sqrt{h}}$$

wherein f_o = the area of the chimney outlet in square feet.

The task of determining the most favourable width of the chimney for any locomotive boiler is thus reduced to applying these two simple equations. A check-up on the basis of the complete blast pipe theory would reveal that variations in superheat, smoke-box temperature, &c., do not have a worthwhile influence upon the value of f_o thus obtained.

The exhaust nozzle area f_1 belonging to the most favourable chimney so defined is again in a most simple relation.

$$(3) \quad . \quad . \quad . \quad . \quad . \quad . \quad f_1 = 0{\cdot}080\, f_o.$$

The constant 0·080 in this equation is good only for a chimney of the relative proportions shown in Fig. 8, and further discussed below. It is somewhat

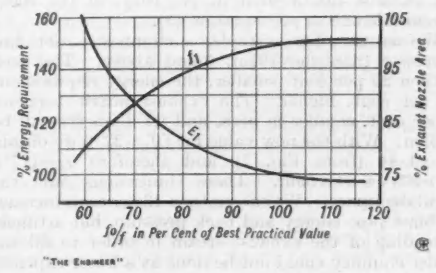


FIG. 9

subject to the grade of fuel, the boiler efficiency, superheat, and steam pressure; the final exhaust nozzle area should therefore either be determined by a detailed calculation according to the complete theory which cannot be treated within the scope of this article, or—and this will be quite satisfactory in ordinary cases—the engine may be equipped with a nozzle according to equation (3), pending final correction in service. The main thing is to choose the correct chimney and relative location of the nozzle, because the energy requirement is determined thereby.

The chimney and nozzle arrangement according to Fig. 8 represents very nearly best practice. The lower flare may be varied considerably without much effect on the performance (see dotted lines). For

[5] The *Railway Engineer*, 1929, page 125.

[6] *Journal* of the Austrian Soc. of Engineers (*Zeitschrift des Oesterr. Ingenieur- und Architekten-Vereines*), 1924, page 373.

other (cylindrical or more nearly cylindrical) chimneys other constants could be established in equation (3), but since they would be less favourable there is no need for them. Fig. 8 is self-explanatory, all dimensions being related to the outlet diameter of the chimney $D_o = 100$ per cent. Only the divergence of the imaginary "steam cone" connecting the exhaust nozzle with the top of the chimney and used for determining the distance a_o between nozzle and chimney outlet needs further discussion. Let

$$x_m = \frac{a_o}{D_o - d}$$

for that "steam cone" which will secure proper filling of the chimney and adequate mixture. Experience shows that x_m grows somewhat with the steam velocity. Adequate expression may be given to the value x_m by plotting it as a function of the relation f/f_1 (flue area by nozzle area), as in Fig. 7. This figure should then be used for the lay-out of the chimney arrangement. It is necessary, however, that in connection therewith the exhaust pipe and nozzle be of smooth shape, so as to promote a vertical, symmetrical steam jet, and the convergent nozzle must not abruptly contract the steam. It should have a taper not much sharper than one diameter in four lengths, and a short cylindrical top portion should be provided.

Let us now determine the most favourable chimney for a 0–6–0 type goods engine having the following boiler proportions :—

Grate area	26 sq. ft.
Flue length	11ft.
171 small flues, inside diameter	1¾in.
18 large flues, inside diameter	4⅝in.
4 × 18 superheater tubes, outside diameter	1⅝in.
Flue area	3·5 sq. ft.
Flue heating surface	H_f = 980 sq. ft.
Superheater heating surface	H_s = 247 sq. ft.
$H_f + H_s$	1227 sq. ft.

We obtain from equations (1), (2), and (3)

$$h = \frac{0{\cdot}905}{100}\left[\frac{1227}{3{\cdot}5} + 100 + \frac{18{,}000}{(7{\cdot}41)^2}\right] = 7{\cdot}05\text{in.}$$

Outlet area of chimney: $f_o = 3{\cdot}5\,\frac{1{\cdot}56}{\sqrt{7{\cdot}05}} = 2{\cdot}06$ square feet, or 297 square inches.

Area of exhaust nozzle : $f_1 = 0{\cdot}080 \times 2{\cdot}06 = 0{\cdot}165$ square feet or 23·7 square inches.

Therefore

Outlet diameter of chimney $D_o = 19\frac{1}{2}$in.

Diameter of exhaust nozzle $d_1 = 5\frac{1}{2}$in.

For the chimney lay-out we obtain the value of x_m from Fig. 7, with $f/f_1 = 3{\cdot}5/0{\cdot}165 = 21{\cdot}2$: $x_m = 4{\cdot}72$. The distance from the exhaust nozzle to the top of the chimney must therefore be $a_o = 4{\cdot}72\,.\,(D_o - d_1) = 66$in.

If the boiler centre is 8ft. 6in. above the rails, and the loading gauge permits a total height of 13ft. 3in., the exhaust nozzle will be positioned 9in. below boiler centre.

We might now make the calculation for a large locomotive, in order to show what should be done if there is not enough vertical space available to accommodate the most favourable chimney thus determined. Instead, we can use the above example, assuming that for some reason there be only about 60in. of height available for a_o. Evidently, we cannot use the calculated chimney, but we can use one of smaller diameter at some expense in form of increased back pressure. The diagram, Fig. 9, has been developed to quickly settle the questions then arising. The curve E_1 shows the percentage of blast pipe energy required for any chimney outlet area f_o if the most favourable area as determined by equation (2) be 100 per cent. The curve for f_1 gives the corresponding exhaust nozzle area in per cent. of the most favourable one as per equation (3).

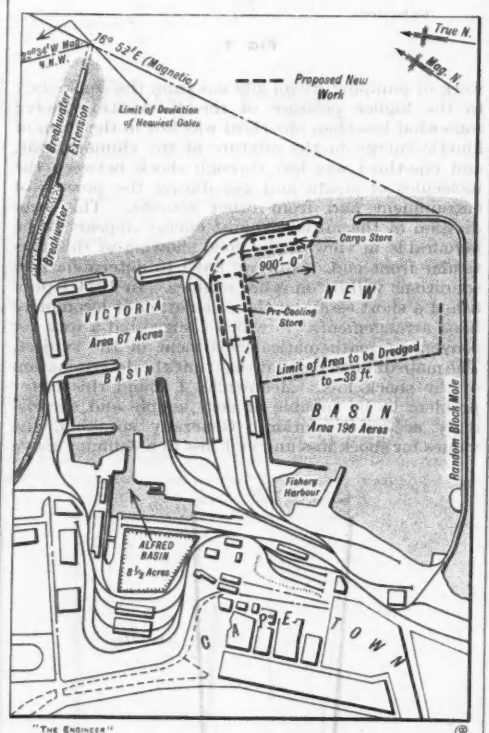
We assume, for example, a chimney outlet 2in. narrower than the 19½in. found above. The area is then 20 per cent. smaller, the energy requirement 13 per cent. higher. The exhaust nozzle becomes 6 per cent. smaller in area, and its diameter will be 5·33in. With the new value for $f/f_1 = 22{\cdot}6$ we obtain $x_m = 4{\cdot}84$ (from Fig. 7), and therefore $a_o = (17{\cdot}5 - 5{\cdot}33)\,.\,4{\cdot}84 = 59$in. These dimensions suit the available space. We encounter a 13 per cent. increase in blast pipe energy and back pressure, but artificial spreading of the exhaust steam in order to fill the wider chimney could not be done at a lesser expense, and therefore the plain nozzle arrangement is still preferable.

Whenever the most favourable chimney arrangement as here determined can be accommodated, steam spreading or "fancy" nozzles cannot bring any increase whatever in efficiency over the plain exhaust nozzle. This should be stated with emphasis, because railway managements can save considerable sums of money if the continuous experimenting with front ends is stopped, at least in those instances where there is definitely no chance of success.

In a similar way, although not with such ease and simplicity, the wide field of special exhaust nozzles can be explored. Another chapter is that of intermediate nozzles, some simple forms of which can be used to advantage in combination with plain exhaust nozzles. Rational application of theory will solve our blast pipe problems where empirical methods have consistently failed and resulted in confusion.

Big Dock Extension at Cape Town.

The enormous development in the import and export trade of the Union of South Africa in the last two and a half years, has brought with it as a natural consequence a great increase in the number of ships entering and leaving Union ports. In the last eighteen months over sixty ships, additional to those previously running, have been put on the South African trade. A further large number are now under construction or ordered, and others are projected. Besides the increase in the number of ships, there is a very considerable increase in the size of the new ships and also in their speed. The existing Victoria Basin at Cape Town was designed to accommodate ships of 12,000 to 15,000 tons, which at the time it was thought would give ample margin. Now, however, there has been a sudden jump in the sizes of ships using that dock, and the Harbour Administration, caught unprepared, is making desperate efforts to meet the position temporarily until a large scheme of additional dock accommodation at Cape Town, Durban, and other smaller ports can be designed. On January 2nd of this year work was begun on a quay to accommodate the 25,000-ton Union-Castle mail boats now being built. This berth is being constructed in the New Dock, which up to then was little more than a sheet of water enclosed by a mole, constructed on the random block system, but leaving an entrance, and having on the side adjoining the Victoria Dock a quay wall and such equipment as would enable a couple of ordinary size steamers to be alongside, but certainly of no use for dealing with 25,000-ton boats. Up to last year the position was that although some



CAPE TOWN DOCKS

£3,000,000 had been expended on dock extensions at Cape Town, there was no safe accommodation whatever for the big new mail steamers being built, and other ships of similar size which are projected.

The present emergency scheme provides one new deep-water berth, 900ft. long, at what is now the "knuckle," and constituting one side of the entrance. This berth will be equipped with modern cranes and rail and road facilities. Adjacent to it will be erected a new pre-cooling plant with a capacity of 4000 tons storage. When this new plant is brought into operation the existing pre-cooling plant, on the East Pier of the Victoria Basin, will be scrapped. The total cost of the new berth, which will be dredged to a depth of 40ft. to 45ft., together with the pre-cooling plant equipment, &c., is estimated at about £750,000, but something like double that amount at least will have to be spent to provide sufficient large berths to meet the demands of the bigger classes of ships now being built. In addition to the two 25,000-ton mail ships being built for the Union-Castle and two 15,000-ton boats for the same company, the German-African lines are starting building two 16,000-ton liners and it is stated that the Italian lines intend building two or more ships of over 25,000 tons for service to South Africa. There are at present eight liners, each over 600ft. long, calling regularly at Cape Town, apart from an occasional tourist ship, so that in all there will soon be at least fourteen of these big ships trading to Union ports, and Cape Town has only four berths suitable for boats of their size, and even the new berth, although being constructed with all speed, will not be ready until 1937, while the first of the 25,000-ton ships is expected to make her maiden trip from England to Cape Town in February next year.

The Nijhoff Harbour Affairs Commission's report, which was published on July 4th last, has not been followed by the Harbour Administration, for it recommends that the entrance to the new dock should be moved in a north-easterly direction, and the width of the entrance should be made 400ft. and perpendicular to the prevailing winds, and suggests that the first quay to be built should be begun at the new entrance and be constructed in the direction of the random block mole—the side of the new dock remote from the Victoria Basin—and should have a length of 1700ft. and accommodation for berthing two large vessels or one large and two medium-sized or three medium-sized vessels. At a later date another quay could be constructed to accommodate one large and two medium-sized or four medium-sized vessels. In the corner where the wall which divides the Fishery Harbour from the new dock is situated, it will, the report states, be possible at a later date to construct a dry dock in a S.S.E-N.N.W. direction, which will not adversely affect vessels entering during strong winds. The report adds that at present the entrance to the dock is at right angles to the prevailing winds, and an incoming vessel with high superstructure receives so much wind during a strong south-easter that even with the aid of powerful tugs berthing is a dangerous matter. Further, once a ship is moored at the side of the quay, adjacent to the Victoria Basin, it is wellnigh impossible to remove it when a south-easter rages. The entrance to the new dock will, it is stated, be unfavourable, no matter what internal arrangements are decided upon. To improve the Victoria Basin, the report recommends moving the entrance to the south-east side, widening the entrance and removing No. 2 jetty. This would place the Victoria Basin in such a condition that it would be able to receive the new mail vessels. The alterations would not take long. Apparently these proposals of the Commission have not met with the approval of the Administration, and even the commercial community is opposed to doing away with the No. 2 jetty, and removing the elbow to make a new entrance, as it would reduce the accommodation by four berths, including two bunkering berths and the only oil discharge berth.

What the comprehensive scheme is which the Minister of Harbours and his experts favour, is unknown, but the harbour experts at Cape Town and the shippers are pressing for the putting in hand of a scheme which provides for the construction of a deep-water berth on the land side of the new dock, big enough to accommodate two large ships, although it was condemned by the Nijhoff Commission. The present dry dock, only able to accommodate vessels under 460ft. in length, is also useless to the great majority of the ships now visiting Cape Town, so that the position in respect to damaged vessels requiring extensive underwater repairs is serious, and would be more so but for the fact that the use of the Admiralty graving dock at Simonstown is always granted by the Admiral commanding the African station when application is made to him. Even this arrangement, however, is not satisfactory, as that entails upon damaged ships the necessity of proceeding round the coast from Table Bay to False Bay, which in bad weather might be dangerous. The Nijhoff Commission's recommendation for the construction of a graving dock has been given above, while there is an alternative suggestion to build it in a corner of the new dock, jutting out at right angles from the mole. During July deputations waited upon the Minister of Railways and Harbours, but all that they obtained from him was a promise that not later than on the completion of the present work—that is, about March, 1937—they would have an opportunity of commenting on a long-distance scheme for the future development of Table Bay Harbour, with special provision for additional all-weather berthage. It is therefore clear that for several years to come the Table Bay docks will be inadequate for the class of vessel now coming forward, although the authorities were warned in good time of the new developments in the number and size of vessels which would use the Union ports.

BRITISH STANDARDS INSTITUTION.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

WIRE ROPES FOR ENGINEERING PURPOSES.

No. 621—1935. The Institution has just issued a Specification for Steel Wire Ropes of Special Construction for Cranes, Lifts, Excavators, and other general engineering purposes.

The ropes covered by the specification are of special construction and should not be installed in place of the ordinary round strand ropes without special consideration being given to conditions of service and maintenance.

The specification is framed on the lines of the previously issued British Standard Specifications for Crane Ropes, Lift and Hoisting Ropes, Oil Well Ropes, Colliery Winding Ropes, and Colliery Haulage Ropes. The specification includes a number of recommendations regarding sizes of drums and pulleys, pulley and drum grooves, angle of lead, and factors of safety.

ALUMINIUM ALLOY BARS AND FORGINGS ("Y" ALLOY); ALUMINIUM ALLOY DROP-FORGINGS FOR PISTONS AND CYLINDER HEADS ("Y" ALLOY).

Nos. 3 L. 25 and L. 43. Of these two specifications, which have just been published by the Institution, the first is a revision of B.S. Specification 2 L. 25, and covers the alloy generally known as "Y" Alloy. It deals with bars and billets for forgings, bars for machining (not exceeding 3in. thick), and forgings (including pistons other than drop forgings). This specification replaces the Air Ministry Specification D.T.D. 191 for "Y" Aluminium Alloy Forgings and Stampings. The second specification is a new one, and replaces the Air Ministry Specification D.T.D. 58A. Each specification is priced 1s. 2d., post free.

HANDBOOK AND ANNUAL REPORT.

The Institution has recently issued its half-yearly handbook, which includes the Annual Report for 1934-35, presented at the last annual general meeting, as well as an indexed list of current British Standard Specifications. Copies of the handbook (reference C D.7000) are obtainable at 1s. 4d. post free.

Rail and Road.

WHAT are usually known as the Railway Returns are a volume of statistics of the capital, traffic receipts, and expenditure, and the statistical returns of all the British railways. Those for 1934 were issued on August 16th, price 6s.

THE London and North-Eastern Railway Company, finding definite signs of a gradual revival in shipbuilding and in the heavy basic trades, and an increase in the iron and steel traffic in the Sheffield and North Lincolnshire districts, has authorised an expenditure of £180,000 upon the reconstruction and re-equipment of the West Quay at Tyne Dock.

THERE was an increase, when compared with the corresponding month of 1934, of 44 per cent. in the number of passengers dealt with at Southampton Docks, Southern Railway, in July last, and of 19 per cent. in the cargo traffic. The increase in passenger traffic is ascribed as due to greater tourist traffic and to that brought by the Naval Review.

THE report, price 3d., of the Railway Assessment Authority, for the year ended March 31st, has just been issued. It refers in detail to the decision of the Railway and Canal Commission against the assessment made by the Authority in respect of the Southern Railway, and mentions that the Authority has appealed to the House of Lords against the decision of the Railway and Canal Commission.

ACCORDING to the Board of Trade Returns the value of the railway material exported during the first seven months of the present year was as follows, the figures in brackets are the corresponding figures for 1934 :—Locomotives, £393,769 (£168,442); carriages and wagons, £635,396 (£432,064); rails, £448,148 (£517,022); wheels, metal sleepers, fish-plates, and miscellaneous material, £1,020,055 (£599,469).

THE passage of the Road and Railway Transport Act for Northern Ireland, mentioned herein on August 9th, has now been followed by an announcement as to the new Transport Board. There are no railwaymen's names mentioned, nor, apparently, those of anyone closely associated with road transport. The Chairman is Mr. D. L. Clarke, who will be a full-time member, and will relinquish his post as Assistant Secretary to the Ministry of Home Affairs.

IN December, 1891, a demonstration was carried out by Mr. James Holden, the locomotive superintendent of the Great Eastern Railway, as to how quickly a locomotive could be erected. The engine was of the six-coupled goods type, and it was put together in the record time of 9¼ hours. Under its original numbering it was "No. 930," and became "No. 7930" in the L.N.E.R. stud. It has now been broken up, after running 1,127,750 miles, because its class has become obsolete.

THE forthcoming retirement of Mr. W. H. Liley, who ranks as deputy chief engineer (signals), Great Indian Peninsular Railway, prompts a reference to the fact that he was one of four men who, after serving under Mr. W. Powell, the signal superintendent of the Taff Vale Railway, have come to fill high positions in railway signalling. The other three men are: Mr. H. E. Morgan, divisional signal and telegraph engineer, L.M.S. Railway; Mr. H. F. D. Page, assistant signal engineer, Great Western Railway, and Mr. W. H. Powell—Mr. Powell's son—general manager and director of the Westinghouse Brake and Signal Company.

THE Metropolitan and Great Central Joint Committee announces that on and from December 1st, 1935, the branch railway between Quainton Road and Brill will be closed to all traffic. Besides the main line station at Quainton Road and the terminus at Brill there were, on this 6¼ miles branch, three intermediate stations. It was opened in 1872, and known as the Wotton Tramway. In 1894 plans were prepared for its extension to Oxford and the name was changed to the Oxford and Aylesbury Tramroad. The line was leased to the Metropolitan Railway in 1899, and passed to the Metropolitan and Great Central Joint Committee in 1906.

IN view of the fact that it will be one hundred years tomorrow—August 31st—since the Royal Assent was given to the Bill for the Great Western Railway Company to build a line between Bristol and London, it may be remarked that on May 5th last it was the centenary of the opening, from Brussels to Malines, of the first railway in Belgium, whilst the first railway in Germany—from Nuremburg to Fürth—was inaugurated on December 7th, 1835. By this time one hundred years ago the Stockton and Darlington, on September 27th, 1825, the Canterbury and Whitstable on May 3rd, 1830, the Liverpool and Manchester on September 15th, 1830, and the Leicester and Swannington on July 17th, 1832, had been opened. The Grand Junction and the London and Birmingham were authorised in 1833.

AN unfortunate collision occurred at Kildwick, Midland Railway, on August 28th, 1875—sixty years ago. It was unfortunate, not only in its results—seven passengers killed—but because the block system, which was then being installed on that section of the line in anticipation of the opening of the Settle and Carlisle the following year, was approaching, but had not reached, Kildwick. A passenger train was unexpectedly stopped in the station because the tail lamp was out. A second train was following which should have been given the usual time interval of five minutes, but it was allowed to proceed immediately it arrived at the station in the rear. Added to that, the driver of the second train ignored the distant signal, which was against him, and the collision followed. On September 1st, 1905—thirty years ago—a serious accident happened at Witham, on the Great Eastern Railway, when an express, running at about 70 m.p.h., was, except the engine and tender, wholly derailed. Ten passengers and one servant were killed. At first no cause for the derailment could be found, but six weeks after the accident it was learnt that on the morning in question some platelayers who were working at a crossover-road and who affirmed that they had only opened out the ballast, had also taken out some keys from the knuckle of the crossing.

Miscellanea.

A NEW electrically operated steel swing bridge, which is to cost some £13,760, is to be erected to replace the existing timber bridge over the Forth and Clyde Canal near Bonnybridge.

WHAT is believed to be the largest electric clock in the world has been built for the Rand airport. It has a dial diameter of 30ft., with a minute hand 17ft. long and an hour hand 14ft. 6in. long.

ACCORDING to the Berlin correspondent of the *Financial Times*, forty-three motor lorries have left Berlin on the Avus motor road for a trial run to last eight weeks, during which only German-made motor fuel is to be used. Among the different types of fuel employed are wood, charcoal, coke from lignite, coal and peat, anthracite, Diesel oil, Ruhr petrol, and methanöl.

As already announced the Glasgow Corporation proposes to build a new bridge erected to cross the Clyde between Finnieston and Plantation. Eight premiums of £200 each are to be paid for the eight best designs. Several firms have been invited to tender, but it has still to be decided whether the bridge will be of iron and steel or ferro-concrete. The new bridge is to be 70ft. high, and is expected to cost £1,200,000, of which £400,000 has been expended on the purchase and preparation of sites on both sides of the river.

WE record with deep regret the passing of Mr. W. E. Butcher, of the British Thomson-Houston Company's London office, on August 14th, at the age of sixty-two. Mr. Butcher was an old servant of the B.T.H. Company, having joined the staff at Rugby in 1902, and served as a commercial engineer for eight years in Rugby and twenty-five years in the London office. Before joining the company he was on the staff of Crompton and Co. at Chelmsford, having gone there from Hollinwood, where he was on the staff of Ferranti, Ltd.

ONE of the largest of the public works in progress in the United States—the 42 million dollar Triborough Bridge in New York City—is progressing rapidly, and is scheduled to be completed next summer. The bridge joins three boroughs of New York City across Hell Gate and adjacent waters. Its length is nearly 3½ miles, exclusive of some 14 miles of boulevard connections, which are a part of the project. Four river crossings, of which one is a 1380ft. span suspension bridge, are connected by steel girder viaducts in spans of 65ft. to 140ft.

IN the cleaning of tin-lined steel and copper vessels used in the dairy industry, the tin is removed by the chemical attack of the hot solutions of sodium carbonate used to remove milk films. These solutions attack and remove the tin, forming a soluble stannite. Researches carried out by R. Kerr for the International Tin Research and Development Council, and published by the Council as a technical publication, have shown that small amounts of sodium sulphite added to alkaline solutions cause a great reduction—actually to about one-tenth part—in the attack on tin coatings. Results of several series of experiments are given in the book, and it is deduced that the beneficial effect of the sulphite is due to its power to react with the oxygen dissolved in the detergent solution.

ACCORDING to the *Chemical Trade Journal*, it is reported in the American Press that E. I. du Pont de Nemours and Co. intend to manufacture synthetic rubber from monovinylacetylene. This compound will be separated from the acetylene, from which it is produced, by a process employing temperatures of 100 deg. Cent. below zero. The practicability of utilising these very low temperatures for the process has been proved, after research extending over several years. The du Pont Company is also making under the name "Duprene" a polymerised chlorine derivative, which is being used as a rubber substitute and for purposes for which natural rubber is not so suitable. The new product, however, will be a non-chlorine derivative, nearer in chemical constitution and molecular structure to the natural rubber hydrocarbon.

AN extract in the *Iron and Coal Trades Review* says that the Ruhrgas A.-G., which has developed an extensive system of long-distance gas transmission in the Ruhr and neighbouring districts, recently carried out a test run of a road vehicle from Essen to Königsberg and back, using coke oven gas as a fuel. The trial demonstrated that the gas was a suitable fuel for use in heavy goods lorries, and gives a quite satisfactory efficiency. The distance of approximately 740 miles was covered in 27 h. 42 min. actual running time, the whole journey taking four days. The average speed was 27 m.p.h., and the total consumption of gas 575 cubic metres, or 48·5 cubic metres per 100 kiloms. (60 miles). The calorific value of the gas was 4100 kcals. per cubic metre, a supply being carried in cylinders in a trailer, the gas being under a pressure of 200 atmospheres, and fed to the engine through a special pipe. On the return journey, various additional running tests were carried out, which showed that the use of gas did not result in any carbonisation of the engine, and did not have any deleterious effect on the sparking plugs and valves.

IN February, 1934, the Manchester-Barton power station 41,000 kW turbo-alternator, supplied by the Metropolitan-Vickers Electrical Company, Ltd., set up a record by having run on load continuously for 2979 hours (124 days). After being shut down for 8½ hours for ordinary cleaning, the set was put back in service. On June 21st this year the set was stopped for a routine inspection. During the period of 6½ years since it was first put into commission at the end of 1928 the set has run for 49,468 hours, representing 86·51 per cent. of a possible total of 57,180 hours, and has generated 1,580,908,600 units, giving a running load factor of 78 per cent. In this service the rotor, 83ft. 6in. in length and about 100 tons in weight, has made 4,452,120,000 revolutions, and the coal consumed in producing the steam required to drive the set has totalled about 854,000 tons. The speed of the blade tips on the largest wheel in the turbine is 548 miles per hour, while the surface of the earth in the latitude of Manchester moves round its axis at 625 miles per hour. As a result of the recent inspection, a few very minor repairs were made and the set was put back into service on July 25th for a further period.

Air and Water.

AN air service between Adelaide and Darwin, a distance of some 1700 miles, has been inaugurated.

IT is reported that the offer made last March by the Air Ministry of a prize of £25,000 for the design of a high-speed medium-sized air liner has been definitely withdrawn. The withdrawal is due to the demands now being made on the industry by the Air Force expansion programme.

TWENTY-FIVE vessels with a total gross tonnage of 53,172 were sold by German shipyards during the first six months of the year to foreign countries. The value of these vessels is stated to be about £1,000,000 and two of the vessels, worth some £240,000, were bought by this country.

ACCORDING to statements in the American Press, the construction of two American liners, each to be larger and faster than the "Queen Mary" and the "Normandie," is under consideration in Washington. The estimated cost of such vessels is £10,000,000 each, and they would be some 1250ft. long, and capable of 38 knots.

IN a report to the League of Nations Organisation for Communications and Transit, the Chinese Government announce that preliminary work is in hand on a new harbour costing about £4,000,000, on the north side of Hangchow Bay. The port, which is called the Great Eastern Harbour, will take some fifteen years to complete, and when finished will prove a rival to the port of Shanghai.

A NOTE in *The Times* states that Adelaide Airways, Ltd., a new company which is to be managed by the Adelaide Steamship Company, has placed an order for two Jubilee S.T. 25 Monospar monoplanes as the first units of a fleet to maintain a frequent service from Adelaide to Port Lincoln, the York Peninsula and Kangaroo Island, in South Australia. The service will begin early next year.

THE Air Ministry is acquiring land along Porthneigwl foreshore, South Carnarvonshire, for an R.A.F. base. Some 800 acres are required for the scheme, and it is expected that work will begin before the end of the year. Porthneigwl foreshore, which extends from Cilan Head to Rhiw Mountain, is 3 miles long, with large flat lands, and, according to the Air Ministry, is the only suitable place to be found on the Welsh coast.

A STRATOSPHERE glider, now being built in the U.S.S.R., consists of a balloon with a special frame in the lower part of the envelope to which the wings of the glider are fastened. Upon reaching an altitude of about 60,000ft., the glider will be detached from the envelope and it will then start a nose-dive, on coming out of which it will proceed on a gliding flight. It is estimated that the glider will reach a speed of more than 260 miles an hour at this height.

A COMMUNICATION to *The Times* from its Berlin correspondent states that the return voyage on the Zeppelin service between Friedrichshafen and Rio de Janeiro *viâ* Recife is to be shortened by about twenty-four hours. Shorter stops will be made at Recife and Rio de Janeiro. The present scheduled time for the return voyage is just over ten days, so that the airship should now reach Friedrichshafen in about nine days.

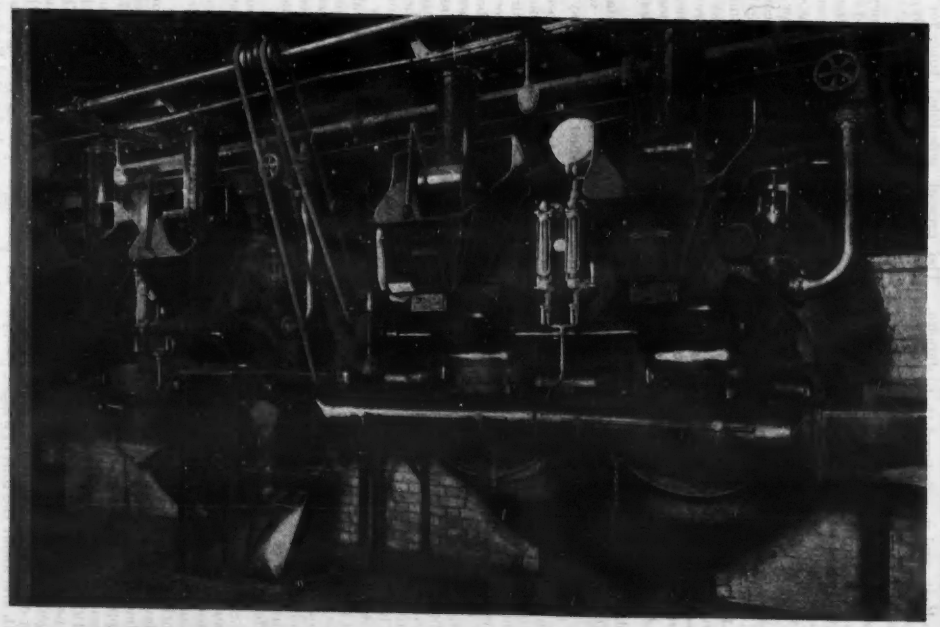
WHAT is claimed to be the fastest journey ever made from New York to Budapest was completed on July 26th when a passenger who left New York in the ss. "Ile de France" of the French Line, at mid-day on July 20th, flew from Plymouth, *viâ* London to Budapest, arriving in Budapest only six days after leaving New York. This journey was made possible by the use of a combination of Imperial Airways Special Charter service and the regular Imperial Airways daily service London–Budapest. One of the planes of the special charter fleet was sent to Plymouth where a special launch and car were in readiness to convey the passenger to the aerodrome, whence he flew to Croydon. The passenger, who had booked through to Budapest from New York, left Croydon at 9 a.m., and arrived in Budapest the same evening. He had thus travelled approximately 4200 miles in six days, five days being spent in the 3000 miles sea journey, while the last 1200 miles were accomplished in a single day by air.

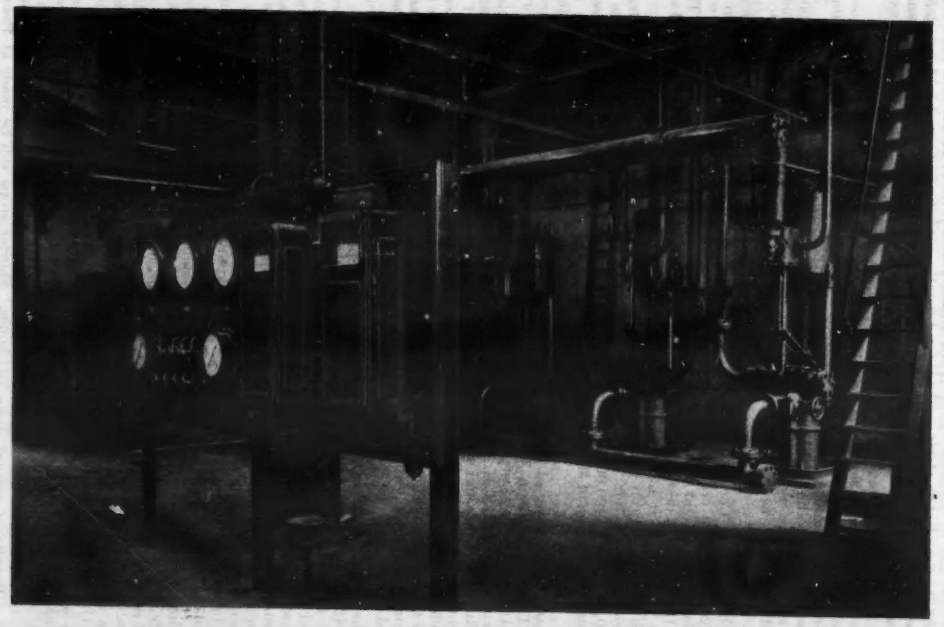
A NEW transmitting system which has been developed by the U.S. Bureau of Air Commerce, is now, according to *Flight*, in practical operation at Pittsburg, Pa. This broadcast and radio beacon can transmit vocal and directional signals simultaneously, so that in bad weather a pilot can hold his machine on the beam by means of a dashboard indicator, whilst receiving aural instructions or information from the airport. The directional signals, which are Morse A and I on either side of the beam, interlocking as usual into a continuous signal on the correct course, can also be received satisfactorily through the pilot's earphones. The new off-course signals are aurally more easily distinguishable than the present Morse A and N. If a machine is not equipped with the dashboard indicator, the pilot has only to move a switch to receive either beam signals or broadcasts in his earphones. The Pittsburgh transmission, incidentally, registers on a direction-finding needle without the fluctuation which is inevitable with the standard beam signals.

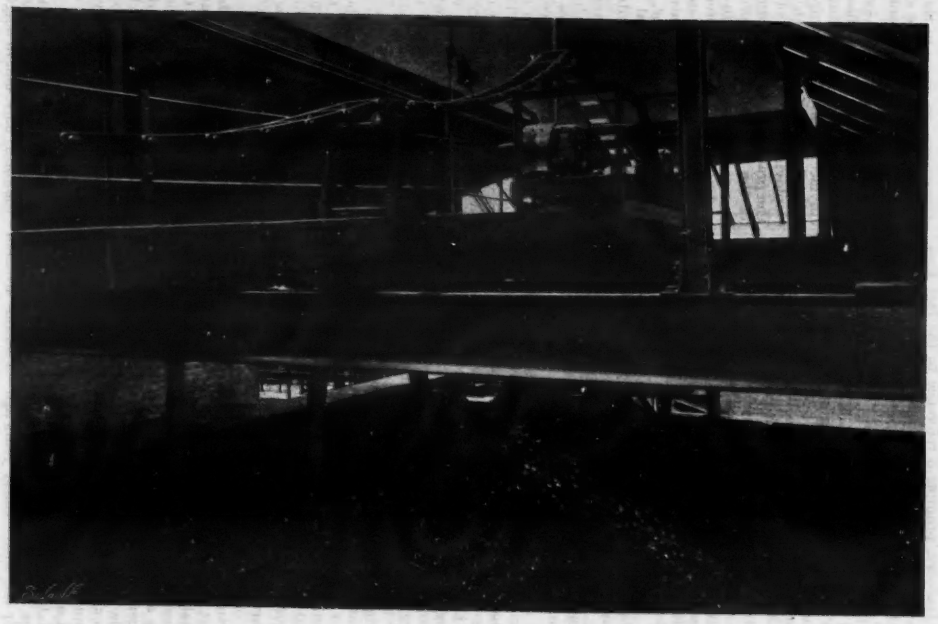
RECENT statistics show remarkable increases in the passenger and mail traffic carried by Imperial Airways. During the first three months of this year, the figure for passenger ton-miles was 564,835, as compared with 367,038 for a similar period in 1934. For freight ton-miles the figure was 127,213, compared with 87,811 in 1934. The ton-mile figure for mails increased from 135,056 to 269,425; while the passenger-mile total reached 5,884,234, as compared with 3,830,609 for 1934. The figures for May this year show an increase of 70 per cent., as compared with a similar period in 1934, in the number of Empire air passengers passing through the London airport at Croydon. On the India and Eastern route during May the passenger traffic growth was in the neighbourhood of 100 per cent., as compared with 1934, while mail loads increased by approximately 60 per cent. During the twelve months from March 31st, 1934, to April 1st, 1935, the air liners of Imperial Airways, operating on the European and Empire routes, flew 2,482,864 miles and carried 55,559 passengers and over 2,000,000 lb. of mails and freight.

BOILER PLANT AND EQUIPMENT AT A LONDON BREWERY

(For description see page 228.)







ABOVE:—THOMPSON BOILERS WITH BENNIS STOKERS
BELOW:—DRIVING END OF COAL CONVEYOR

ABOVE.—BOILER INSTRUMENT STAND AND FEED PUMPS
BELOW:—COAL CONVEYOR OVER OLDER BOILERS

The Engineer

AUGUST 30, 1935.

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SIXTEEN-PAGE SUPPLEMENT—"THE METALLURGIST."

NOTICES TO READERS.

**** If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

**** For Subscription rates, see page 2 of Advertisements.*

**** All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

**** No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGES OF ADDRESS.

**** Will subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

The Metallurgist.

THE AUGUST NUMBER OF
THE METALLURGICAL SUPPLEMENT TO
"THE ENGINEER" ACCOMPANIES THIS ISSUE.

BREAKWATER FAILURES.

THERE is something very impressive about the way in which Nature often seems to get the better of the skill and ingenuity of man in his efforts to provide effective and stable barriers to break the force of the sea waves. Time and again breakwaters built to accord with the results of the accumulated experience of the day have failed in whole or in part under the onslaught of some storm, or series of storms, which at the time were said to be of unprecedented fury. One of the earliest failures of modern breakwaters built on a large scale was that of Alderney, the building of which began in 1847. Among other instances of serious and widespread failure brought about by wave action have been breakwaters at Madras, Bilbao, Sandy Bay (Mass.), Barcelona, Bizerta, and Tynemouth. A more recent example of destruction is the breakwater at Antofagasta, in Chili, a considerable part of which collapsed during a violent storm in the winter of 1928, the wreckage being completed by another storm in the following winter. The recorded histories of the design and failure of these structures show that in the case of many of them widespread damage or collapse has been brought about by the action of waves of much greater height and length than had been considered, when the design was made, as of possible occurrence in the neighbourhood of the work. This common feature of the history of failures is again evidenced by the recent destruction of two important and quite modern breakwaters in the Mediterranean. The eastern mole at Catania, on the coast of Sicily, was badly damaged by three storms which occurred at intervals spread over a year in 1930–31; most of this damage had been made good when another storm of still greater violence in March, 1933, overturned nearly the whole of the outer arm of the mole, 500 m. long. The greater part (400 m.) of the outer arm of the Mustapha Jetty at Algiers, an illustrated description of which appeared in our issue of May 11th, 1934, collapsed, and was destroyed in the most complete fashion during a violent storm on February 3rd, 1934. The stories of the failure of these two important sea works are of the greatest interest to harbour engineers. In addition to the evidence they afford of the lack of precognition of the magnitude of the wave action for which provision should have been made, they indicate certain weaknesses of design that, in Mediterranean practice at any rate, have hitherto not been sufficiently appreciated. These failures are fully described in two important papers which will be discussed at the sixteenth International Congress of Navigation in Brussels early in September. The first of these reports is by Professor Coen Cagli, the Italian engineer whose reputation as a builder of harbours is international, and on whom there seems to have fallen the mantle of his great predecessor, Luigi Luiggi. Signor Cagli critically examines both failures. The second paper by Messieurs Benezit and Renaud, deals mainly with the disaster at Algiers. The two breakwaters and the causes of their failure have also been described and discussed in several articles that have appeared recently in the Italian and French technical Press, and Signor Cagli, in July of this year, delivered before the Institution of Civil Engineers, a lecture on "Italian Harbour Works," in the course of which he demonstrated the inherent weakness and insufficiency in certain respects of both the Algiers and Catania designs. He showed by evidence, which seems to be conclusive, that the failure at Catania was caused by a weakness for which adequate provision had been made at Algiers, whilst the Mustapha failure occurred in a part of the structure, or rather its foundation, which was immune from serious attack at Catania. The lessons to be learned from these occurrences are of great importance.

A brief summary of the facts and of Signor Cagli's conclusions may be of interest. The east mole at Catania is exposed to heavy storms from the east-south-east. The outer arm consisted of a cyclopean block wall, 12 m. wide, each of the blocks weighing about 300 tons, surmounted above water level by a mass concrete capping and parapet, and founded at a level of 12·5 m. below mean sea level on a rubble stone mound of the usual character. The mound, in a depth of water of about 18 m., was protected on its outer face by concrete apron blocks and large stones, the berm being 12 m. wide. It was originally intended to make the cyclopean blocks with core holes to be filled with reinforced concrete after the blocks had been set, in order to key together the units forming each vertical pier. This keying was, however, omitted in carrying out the work, and the blocks were made solid. No packing or lead bedding was provided in the horizontal joints between the blocks. The storms of 1930 and 1931, during which waves about 7 m. in height in the open, and having a length exceeding 200 m. were recorded, caused the movement of many of the blocks and part of the mass capping in the direction of the harbour face of the structure, the blocks sliding one on top of another. All this damage had been made good before the storm of March, 1933, when waves 7·5 m. high and 230 m. long were observed. On this occasion the superstructure, practically the whole of the two upper courses of blocks, and many of the blocks in the layer beneath slipped and were thrown pell-mell into the harbour. Relatively little damage was done to the rubble mound and the apron blocks protecting it. During this storm it is said that waves broke in front of the wall. The design of the Mustapha Jetty, which, in general form, is similar to the mole at Catania, provided for adequate keying between the blocks in individual piers, and also between adjacent piers, as will be seen by reference to the drawings in our description of the work. The cyclopean blocks were founded at a level of 15 m. below water level; but the berm of the rubble mound had a width of no more than 6·4 m. Moreover, at Algiers, the sea bed on which the rubble mound rests, in a depth of from 19 m. to 20 m. of water, consists of fine sand, apparently easily erodable, which extends to a depth of from 8 m. to 10 m. For some unexplained reason the original design for the Mustapha Jetty was not adhered to, the horizontal bond between the blocks being almost entirely eliminated, the core holes being merely filled with rough stones and quarry waste, except the two cores near the seaward face in the two upper blocks, which were filled with concrete. Neither were the horizontal joints between the blocks filled with any kind of packing. As the result, however, of some damage done to the jetty by storms in the winters of 1930 and 1931, and especially after the failure of the Catania mole, the engineers at Algiers realised that it was necessary to revert to the original design, which, if it had been followed, would have ensured the monolithic character of the piers. They therefore proceeded to reinforce the wall by injecting cement into the core wells, by inserting steel reinforcement into vertical bore-holes, and by filling, so far as possible, the horizontal joints between the blocks with cement. This consolidation of the structure was nearing completion, and, in addition, the sealing of the vertical joints on the last 500 m. of the jetty was about to be begun, when, on February 2nd and 3rd last year, the work was attacked by a storm, characterised by a total absence of wind, and by rollers having a wave length of 300 m. and a height of 9 m. in the open sea. Four hundred metres of the outer part of the breakwater suddenly collapsed, overturning towards the sea side. The cause of the disaster is clear. The wall collapsed owing to the scouring of the sand in front of and beneath the rubble base by the back draught and suction caused by the heavy swell. The wall fell or slipped bodily into a hole scoured in some places to a depth of 10 m. in the sand overlying the harder substrata.

Signor Cagli's analysis of both disasters leads him to the conclusion that the Mustapha Jetty would have safely withstood the storm to which it was exposed but for the erosion of the unprotected sea bed, and, on the other hand, that if the Catania mole had had the same monolithic character as the Mustapha Jetty, it would have withstood the attack to which it was subjected in March, 1933, and have emerged from the trial without irreparable damage. Observations of pressures caused by sea waves which have been made at Genoa during the past two years, and model experiments carried out at the University of Lausanne, lead to the conclusion that the depths at which wave action can have destructive effect have, in the past, been under-estimated in the case of many Mediterranean harbours, and Signor Cagli considers that in situations where the sea bed consists of loose material, easily erodable, and at no great depth, the adoption of the vertical wall type of breakwater might entail the necessity, prohibitive from the economic point of view, of protecting the bottom in front of the outer toe of the work over a considerable width by suitable means, such as a layer of quarried stone laid directly on the sea bed, or on a mattress of facine work. In the case of several breakwaters of the composite vertical wall type built in Italy in recent years, the depth adopted for the base of the wall has proved insufficient to ensure the stability of the mound and apron blocks. In some cases this evil is now being remedied by increasing the width of the berm and by flattening the outer slope of the mound. It is noteworthy that Messieurs Benezit and Renaud, who have been chiefly responsible for the works at Algiers, come to very much the same conclusions in the report they have prepared for the Navigation Congress as those arrived at by Signor Cagli. In the reconstruction of the Catania mole and the Mustapha Jetty now being carried out, the original designs of vertical walls have been abandoned. At Algiers the form of the new work follows the classic Marseilles pattern of a wide rubble mound protected on the sea face by concrete blocks deposited pell-mell to form an outer slope brought up to the level of the top of the mass concrete superstructure. At Catania the mole is being rebuilt, on a line inside the foundations of the ruined breakwater, in the form of a rubble mound brought up to water level, protected on its sea face by large concrete blocks, and surmounted by a heavy mass concrete capping.

Education for Leadership.

AT the end of July each year there is always a harvest of educational dicta. Bishops, schoolmasters, soldiers, business magnates, with very occasionally an engineer or a scientist, make speeches at prize-givings and tell schoolboys, their parents, and their guardians, what education is intended to do and how it should do it. Speaking generally, these speeches display broad wisdom, and frequently condemn scholastic systems. Indeed, one is often struck by the large vision of the headmasters of great public schools, and rather alarmed by the much narrower vision of the professors and directors of technical colleges. A distinction is,

of course, inevitable, but it is not unfair to ask if the principle should not be the same. To put it in a nutshell, the public school master aims at making the boy a useful citizen, whilst the technical college professors think only of making him, let us say, an engineer. There is, as it were, a sudden change of aim just at the critical age of the student. Until he is eighteen or so, the boy has not been expected to think overmuch about his career. Then, quite suddenly, the broad education designed, in principle at least, for the expansion of his mind and the inculcation of "morals" is changed for a highly specialised education to fit him for a technical occupation, and so provide him with the means of earning his livelihood. Only at the great universities where many subjects may be studied has he much opportunity to carry on his general education, and even there only by special endeavours, or by seeking contact with those whose immediate serious interests are different from his own.

Aristotle, with his profound knowledge of principles, even when his facts were wrong or incomplete, opens one of his books—"On the Parts of Animals"—with this observation: "Every systematic science, the humblest and the noblest alike, seems to admit of two kinds of proficiency; one of which may be properly called scientific knowledge of the subject, while the other is a kind of educational acquaintance with it. For an educated man should be able to form a fair offhand judgment as to the goodness or badness of the method used by the professor in his exposition. To be educated is, in fact, to be able to do this; and even the man of universal education we deem to be such in virtue of his having this ability" (Ogle). Is not the distinction that Aristotle here makes a very significant and very important one? He seems to draw a line between the man with "scientific knowledge"—what we should now call the scientific specialist—and the educated man, the man, that is, who has developed the gift of being able to distinguish between the good and the bad, the logical and the illogical, in the "method" employed in any branch of knowledge, whether it be one in which he has been specially trained or not. Every now and then the scientific world is startled by the astounding knowledge of some subject, entirely outside their customary sphere, which is exhibited by judges and barristers. It is supposed that they have acquired it by listening to the arguments and the statements of expert witnesses. But we think it may be safely said that if they had not developed in themselves the qualities of "judgment" to which Aristotle alludes, they would never be able to divorce the "goodness" from the "badness" of the evidence put before them, nor to express their opinions or decisions with the lucidity and correctness which characterises them. No doubt it is only the greatest minds that attain these high flights; no doubt the exponents by years of contact socially, in their clubs, at institutions, by reading, and in other ways, and by a quickness and acuity of mind which only a few can be expected to possess, have absorbed knowledge of many things and have stored away subconsciously the underlying principles of many sciences. They have, in fact, made themselves men of "universal education."

Is it not probable, nay, is it not an absolute certainty, that engineering of the future, possibly even the engineering of to-day, will call for or is even now calling for men with the same breadth of education? Our young men are compelled by circumstances to specialise, even the best universities failing to discover means of making more than a few months of a curriculum common to all branches of technical education. Then, on leaving college their works training may, if they are unfortunate, continue to be specialised. The consequence is that we are rearing a race of specialists, of whom few have had the opportunity or the zeal to drive their interests into other channels. Just as the admirable old-fashioned millwright who could turn his mechanical intelligence upon any work that presented itself has almost gone, so the old class of engineers who could design bridges or locomotives, ships or railways, is disappearing from our midst. We know full well that this is the result of circumstances, but when we look around and observe that the heads and leaders of many industries are not, and cannot be, specialists, we wonder if at any rate some of our younger men ought not to be encouraged from the first to abhor specialisation, and be so trained that they could "form a fair offhand judgment as to the goodness or the badness" of any scheme put before them. There was a technical school once which made that its aim. It exists no more; the craving for qualifications and degrees killed it. But we can imagine no more interesting experiment than that a group of young men, probably at a university, should say, "We mean to be leaders of industry; with that as our object we shall take no account of specialist degrees, but shall devote our years to making educational acquaintance with all sorts and kinds of subjects, and shall continually seek the society of those who will talk to us of subjects about which we know least. We will travel also and see what the world is doing, and in the end we may acquire the gift of judgment which will make us useful in any sphere." It would be a grand experiment; some would fall by the wayside; but some would reach the high peaks of industry.

Electrical Contacts.

By G. WINDRED.

The Selection of Suitable Materials.

It would be difficult to over-estimate the practical importance of contacts and contact materials in the electrical industry, and yet this subject has received remarkably little attention from electrical engineers. The object of the present article is to outline the problems presented by a consideration of contact materials and to stimulate the further research on this subject which seems to be very necessary.

General Considerations.

In the majority of cases, and especially with inductive circuits, it is difficult to obtain arcless breaking of an electrical circuit. The conditions necessary for elimination of arcing can be determined mathematically, but can rarely be satisfied in practice, so that the presence of an arc must in most cases be regarded as an inevitable consequence of circuit interruption.

In circuits containing self induction or capacity, there may be a considerable amount of energy stored in the circuit under normal conditions. On breaking such a circuit this energy must be released, and appears at the contacts in the form of a spark, which may in some cases extend itself into an arc as the disconnection process continues. It is the object of all circuit-breaking devices to eliminate the arc in the quickest possible time without material damage to the contacts; but although these are usually the most important functions required of the contacts, they are by no means the only ones. It is also necessary in many cases that they shall carry considerable currents for long periods without suffering any physical modifications which might adversely affect their circuit-breaking properties.

From these considerations it is evident that there are two fundamental and not necessarily related properties which must be fulfilled by all electrical contacts in order to approach ideal operating characteristics, viz.:—

(*a*) Ability to carry the rated current continuously when the contacts are closed, without excessive heating or other effects detrimental to the operation of the contacts.

(*b*) The ability to dissipate the maximum arc energy of the circuit and without excessive disintegration of the contact faces, or other effects detrimental to the current-carrying properties of the contacts.

Detailed consideration of these conditions necessarily covers most of the problems connected with the selection of contact materials for different purposes, so that it will be advisable to discuss the above properties as fully as possible.

Taking first the conditions outlined under (*a*) above, it is evident that the heating at the contact faces, which is the most important part of the total heating in so far as preservation of the contact faces is concerned, depends upon the actual contact resistance. It is an unfortunate fact that comparatively little is known concerning this important phenomenon, perhaps on account of the difficulty of formulating a satisfactory theory. We can, however, give an outline of the salient points.

Contact Resistance.

When two electrically conducting materials, either similar or dissimilar, are placed in contact, the electrical resistance across the junction or interface between the two materials has a definite value, which is known as the "contact resistance," depending upon the physical condition of the respective contact faces, and the mechanical pressure acting upon them.

The electrical properties of a junction between dissimilar metals have received considerable attention in the past. Thus the Seebeck effect, relating to the e.m.f. produced upon heating and cooling such a junction, is used extensively in high temperature pyrometry. The converse of this phenomenon, known as the Peltier effect, and relating to the heating of such a junction by the passage of a current, is of more direct interest from the present view-point, and has formed the subject of a large amount of theoretical investigation having an important bearing on thermo-electric phenomena.

In all considerations of contact phenomena the types of metal employed are of fundamental importance, and in this respect their relative cost must also be considered in practice. It is evident that small contacts, such as are employed in telephone relays, magnetos, thermostats, and similar light contact devices require only a small amount of material, so that even when the very expensive noble metals and alloys are employed the cost of the contacts forms a normal percentage of the total cost of the apparatus. In heavy-current engineering practice, however, the contact problem is rendered much more difficult by the fact that the high cost of these special materials results in an entirely disproportionate contact cost which would, in many cases, be quite prohibitive. It follows that in the design of contact devices for power currents the choice of contact materials is limited to those of relatively low cost.

In practice, one of the most important factors affecting contact resistance is the possibility of an oxide forming on the contact faces, as this forms a relatively high-resistance sheath which increases the contact resistance and therefore increases the amount of heat generated at the interface. The consequent increase of temperature usually results in an increase in the thickness of the oxide film, so that the effects are cumulative and may produce serious overheating of the contacts. If the metals employed are susceptible to the formation of an oxide, it is evident that means must be adopted for the complete or partial elimination of this possibility. The methods of achieving this result may be considered as follows:

(*a*) Plating of contact faces with a non-oxidising metal. This can be regarded only as a temporary measure, since the normal operation wears away the protective covering at the point of contact, which is the part it is desired to protect.

(*b*) Mechanical wiping or scraping, either inherent in the design, as with laminated or sliding contacts, or performed manually by filing at suitable intervals. In the former case the device may not operate frequently enough to eliminate the oxide effectively. The latter method must be regarded as impracticable in most cases.

(*c*) Electrical arcing, usually an inherent quality, tends to eliminate the oxide, so that frequent operation on load is desirable from this point of view. The frequency of operation is usually determined by the operating conditions, so that this alternative can scarcely be regarded as a solution to the problem.

With copper contacts, which form by far the greater proportion of those used in heavy current practice, exposure to air results in the formation of a film of copper oxide (CuO). The rate of production and the thickness of this film increase with temperature, so that in order to minimise the contact resistance and subsequent heating thereby introduced, it is necessary to keep the current density to as low a value as possible. In the case of metals which do not oxidise at ordinary ambient temperatures, the contact resistance decreases with increase of temperature until the oxidation point is reached, and then increases rapidly owing to the cumulative effects of oxide formation.

It has been noticed that with copper contacts heated in this manner there is at a certain critical temperature a sudden decrease, both of resistance and temperature, which brings these values down to about normal. This factor is probably due to activation of the copper, resulting in the copper oxide film being changed to Cu_2O suddenly at the critical temperature. The new film thus formed is of lower resistance, so that the heat generated at the interface is reduced to a lower value.

In practice, a covering of vaseline or oil of some kind is frequently applied to contact faces with the object of preventing oxidation. While it is true that a covering of this kind does actually retard the oxidation process it has the general effect of increasing the contact resistance. There is, moreover, the serious objection that the covering tends to accumulate dirt or other particles of matter which may happen to be present, and which usually carbonise under the action of the arc, or of normal heating at the contact faces, thus giving rise to a further source of trouble.

The difficulties inherent in the use of copper contacts have given rise during recent years to considerable investigation of the practical possibilities of other metals for contact purposes. The fact that silver, which is a relatively inexpensive metal, has a relatively low resistance oxide, led very quickly to the use of silver contacts for numerous purposes, especially in view of the fact that the contact resistance of silver is as low or even lower than that of

copper. There are, however, in addition to the possible question of price, two serious objections to the use of silver for heavy current purposes :

(i) The metal is relatively soft, so that under given conditions the mechanical life will be short.

(ii) It has a low melting point (considerably lower than that of copper), so that it is in general more rapidly disintegrated by the effects of arcing.

These facts will be apparent from Table I, which gives the principle characteristics of the usual contact metals as distinct from alloys, which are listed in Table II.

TABLE I.—*Contact Metals.*

Metals.	Fusing point, ° C.	Thermal cond., cal./c.m./sec./° C.	Resistance, microhms per c.m.³.	Temp. coeff. of resis.	Brinell hardness, annealed.	Specific gravity.
Copper ..	1083	0·92	1·72	0·0040		8·93
Silver ..	961	1·006	1·62	0·0036	30	10·50
Platinum	1760	0·170	10·5	0·0037	47	21·40
Palladium	1550	0·168	10·7	0·0036	49	11·40
Tungsten	3370	0·360	5·5	0·0052		18·80

TABLE II.—*Contact Alloys.*

Alloy.	Fusing point, ° C.	Brinell hardness, annealed.	Specific gravity.
Coin Silver	890	59	
10 per cent. gold-silver ..	1000	28	11·38
10 per cent. irid.-plat. ..	1820	150	21·50
20 per cent. irid.-plat. ..	1880	230	21·64

The above figures have been collected from various sources, and therefore do not in every case relate to identical conditions. They are intended solely as a means of comparison and are sufficiently accurate for this purpose.

THEORY OF CONTACT RESISTANCE.

It appears that for any shape of contact, the contact resistance R, is related to the pressure P between the contacts in accordance with the simple formula :

$$P r = k, \text{ or } r = k/P.$$

This law is substantially correct for all ordinary contact materials and all normal contact pressures. With kilogramme and centimetre units the value of the constant k varies between rather wide limits, being approximately $0 \cdot 36 \times 10^{-3}$ for clean and dry copper-to-copper contacts, and as low as $0 \cdot 07 \times 10^{-3}$ for similar contacts when tinned. Contact resistance appears to have no definite connection with the specific resistance of the respective materials, but depends upon a variety of conditions related to the crystal structure of the metal and the physical conditions existing at the interface.

Contact resistance is influenced to a large extent by the type of contact face. Although, in practice, large contact blocks with flat surfaces are frequently employed, it has been shown by experiment that a line contact of length x between a cylindrical and a plane contact surface offers only from a half to one-third of the contact resistance measured under similar conditions between two plane contact faces of dimensions x by x.

It has also been found, as might be expected, that ground-in contacts offer less contact resistance than polished ones, this effect being probably due to the fact that for a given pressure there will be more points of contact between the metals in the former case than in the latter.

THE GENERAL PROPERTIES OF CONTACT MATERIALS.

As will be observed from Tables I and II, there are, in many cases, considerable differences between the general properties of contact metals and alloys. Only the properties of general interest from the present viewpoint have been listed in the above table, and may be considered briefly as follows :—

Fusing Point should be as high as possible, especially when large currents are handled, and when there is a tendency to arcing, so as to prevent undue disintegration and roughening of the contact faces due to local melting. The worst performance is given by silver and the best by tungsten, although the latter material, apart from its cost, is rather unworkable and tends to oxidise badly under normal conditions. An intermediate choice rests among the iridio-platinum alloys, pure platinum or palladium, but the cost of these materials is usually too high to be practicable in the case of large contacts.

Thermal Conductivity should be high, to allow most rapid possible transmission of heat through the contact material to the contact support for effective radiation. The best performance in this respect is given by silver, closely followed by copper, while platinum and palladium are relatively poor thermal conductors.

Specific Resistance is directly related to thermal conductivity, in as much as good electrical conductors are good thermal conductors. Since maximum conductivity is desirable, the metals hold the same priority in this respect as applies to their respective thermal conductivity.

Temperature Coefficient of Resistance should be as low as possible, so that the specific resistance does not increase unduly with increase of temperature.

Hardness, measured either by Brinell or scleroscopic methods, is of great importance, and should be as high as possible in order to prevent undue wear, especially where high contact pressures are employed and where the frequency of operation is high. Pure silver and the high-percentage silver alloys give a poor performance in this respect.

Specific Gravity plays an important part in the cost of precious metal contacts, since the limits imposed by the contact dimensions necessitate a greater weight and, consequently, a higher cost, in the cost of a dense metal than in the case of one having a lower specific gravity. The high price disadvantages of platinum and tungsten are further emphasised by their high specific gravity.

CONCLUSION.

It is hoped that the foregoing brief review of the subject may serve to indicate that a considerable amount of research on contact materials remains to be done in order to arrive at satisfactory practice. There is very considerable scope for useful experimental work in this connection, especially in the establishment of contact resistances for the principal contact metals and alloys. It is suggested that this subject might well occupy the attention of scientific and industrial research organisations, with a view to obtaining consistent and reliable data, which would be of considerable benefit to the electrical industry.

A selection from representative literature is given below as a guide for further researches.

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Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

"SILENT" ROAD BREAKERS.

SIR,—The daily Press has recently had much to say about the demon Noise ; in some cases even casting unjustifiable aspersions on the ability or desire of borough engineers to get rid of what seems to be regarded at the moment as Public Enemy No. 1. A few remarks on the subject from an engineer's point of view will no doubt help those borough engineers whose Committees may demand that all road breakers shall be forthwith gagged with cheap and efficient silencers !

Pneumatic road breakers have been in use for over twelve years. All that time they have been cussed and discussed for their noise, and exhaust silencers were fitted more than ten years ago. Many designs, patented and unpatented, have been tried, but none is satisfactory. Moreover, if you listen to a road breaker with a discriminating ear, you will discover two kinds of noise :—(1) The noise of the exhaust, a minor noise, and (2) the ring of the steel when it is struck by the piston, a major noise. Even if you succeed in silencing the exhaust, the most objectionable noise remains. Moreover, even the comparatively simple problem of reducing the smallest noise (the exhaust) is full of troubles, because any silencer yet made either introduces back pressure which reduces the work done, or falls to pieces, as its structure cannot stand the vibration of the tool. Or if it is robust enough to stand the vibration and knocking about, it makes the tool too heavy, and the workmen will not use it.

Usually a combination of all three troubles arises over the exhaust silencer. The analogy of a motor car silencer does not fit the case at all. The initial and exhaust pressures are different. A small back pressure is not detrimental to a motor car engine, and the motor car silencer rests comfortably on a spring-supported chassis. The road breaker has its capacity for work reduced in direct proportion to any back pressure applied, and this increases the time and cost of breaking up a road. The breaker is frequently thrown down on the road or among the *débris* so that the silencer has to be very substantial, and therefore heavy to stand that treatment.

The major noise, *i.e.*, the ring of the metal when struck by the piston, presents an even greater problem. Rubber-cased springs and air cushions have been tried, but they do not retain their efficiency for more than a few hours, due to the punishment these devices get from the piston, which, by the way, strikes 1000 or more blows per minute. Even rubber and asbestos jackets do no more than modify the sound.

Notwithstanding all the demonstrations of so-called silent road breakers, the problem shows no signs of complete solution. So far the best that can be done is to modify the noise, and that has reduced the work done. You have therefore to put up with less noise for a longer time, or a lot of noise for a short period. But any modification of the noise hits the ratepayer's pocket, for the more silent the machine, the longer it takes to do the job, and the higher the labour costs. Those borough engineers who do not fit silencers are therefore saving the ratepayers' pockets, even if they disturb their nerves and in these hard-up days the average ratepayer will tolerate a lot of noise if you can get it over quickly, rather than a little less noise plus an attack on his pocket.

ANDREW STEWART, M. Inst. E.E.

London, W.1, August 24th.

LONG SPAN BRIDGES.

SIR,—I wonder whether any of your readers can state what is the longest span that has been adopted within recent years in bridge construction. Doubtless there are some bridges in America or in other parts of the world which have recently been undertaken and have spans which some years previously it would have been considered impossible to bridge.

August 23rd. BRIDGET.

SIXTY YEARS AGO.

AT the Belfast meeting of the British Association in 1874 Professor John Tyndall had "astonished, shocked, charmed or disappointed" various sections of the community by his remarkable presidential address. In the following year the Association met at Bristol under the presidency of Sir John Hawkshaw. His address was something of an anti-climax. From our issue of August 27th 1875 we gather that it fell quite flat on the ears of those who twelve months previously had been stirred by Tyndall's oratory and daring. Tyndall revealed himself as a materialist. In matter he discerned "the promise and potency of every form and quality of life." Many people felt that the address marked a declaration of war between Science and Religion. Sir John Hawkshaw appeared to recognise that it was hopeless to attempt to emulate Tyndall. As a practical, modest engineer rather than as a man of pure science he could not hope to dazzle, charm or excite his audience. His opportunities were not as the opportunities of his predecessors and throughout his address he seemed to be saying "I have nothing new to tell. Engineering is not new. I can only repeat an ancient tale. We have done nothing that has not been done of old." His audience was athirst for something stimulating. He gave it a few scraps of history and a brief summary of the work and responsibilities of the modern engineer. Sir William Armstrong, an earlier engineer President of the Association, had, we said, succeeded infinitely well as compared with Sir John Hawkshaw. But he had done so by abandoning engineering and by uttering startling theories concerning the exhaustion of our coalfields. The truth, as we saw it, was that there was nothing left to be done in the realm of constructive science which could supply matter for a sensational British Association address. Sir John Hawkshaw, in a word, could not make bricks without straw. His address filled eleven closely printed columns in the issue quoted. It was delivered it seems in a low voice which speedily half emptied the gallery and ultimately led to a polite request for greater audibility. No greater contrast clearly could have been possible with Tyndall's address of a year previous. Nevertheless we found cause to welcome and praise Sir John's address. With our mind obviously on the proceedings at Belfast a year before we confessed that we had no predilection for startling addresses. Sensational science, we said, was unworthy of the age in which we lived. Sir John's simple, straightforward story had set an example to future Presidents that was sorely needed and could not fail to promote the best interests of the Association. . . . Tyndall's memorable address embodied an outlook on life and the universe which has been smashed to ruins by modern physicists. Almost every fundamental principle which it enunciated was contradicted and reversed in the equally startling address which Sir James Jeans delivered at Aberdeen last year. Of Sir John Hawkshaw's address it may at least be said that it can still be studied with profit.

AT a cost of some £200,000, another 16 miles of suburban railway at Bombay is to be electrified.

Performance of Cotterway and Key-seating Machines.

THESE notes have reference to the present-day type of machine in which one or two keyways at 180 deg. cut simultaneously or continued through to meet and form a cotterway, are machined by end mills in multiple reciprocation. Comparison is made with other types of machines.

For a given keyway width and depth in any stated material there are three variables to consider when operating the machine :—

(1) Cutter peripheral speed ;
(2) Depth of cut per reciprocation ;
(3) Rate of traverse of cutter ;

and from (1) and (3) the feed per revolution of the cutter is decided. In order to obtain a maximum production or "spoil" in cubic inches per minute

$$\left(\begin{matrix}\text{No. of r.p.m.}\\ \text{of cutter}\end{matrix}\right)\times\left(\begin{matrix}\text{Depth of cut}\\ \text{per stroke}\end{matrix}\right)\times\left(\begin{matrix}\text{Traverse per}\\ \text{rev. of cutter}\end{matrix}\right)$$

must be a maximum.

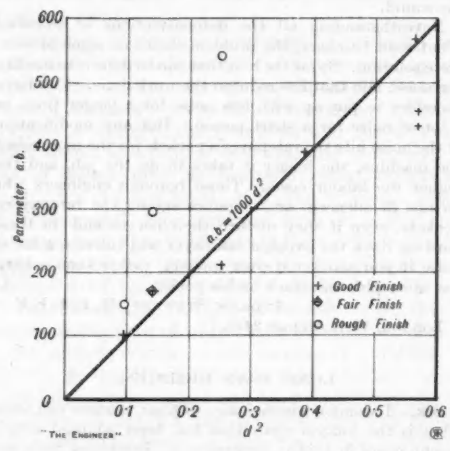


FIG. 1

The first factor is controlled by considerations of cutter life, and has similar limits to those experienced for turning tools and drills, but the other two factors are limited by the nature of the finish required, as an excessive product of (depth of cut)×(traverse per revolution) leads to "jarring" of the overhanging cutter, or, in the limit, to vibration of the table of the machine itself, so that each design of machine has a maximum value of this parameter which is not necessarily that of the possible product for the maximum size of cutter the machine will accommodate.

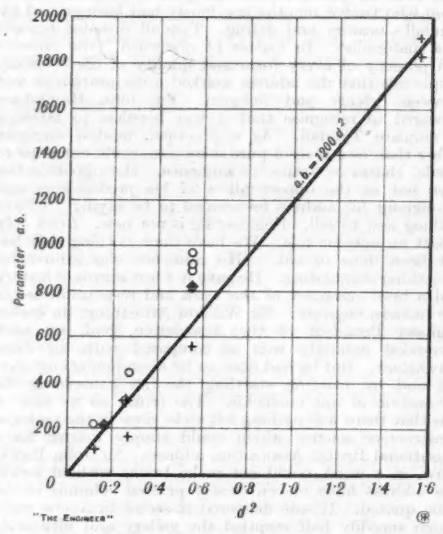


FIG. 2

From many tests the author has arrived at the conclusion that this product should not exceed K d^2, where K is related to the tensile strength of the material cut ; when depth of cut (a) and traverse per revolution (b) are given in units of 0·001in.; then

$$a\,.\,b=\frac{38{,}000\,d^2}{\text{Tensile strength (tons/sq. inch)}}$$

Also following usual works practice, the peripheral speed of the cutter has been made equal to

$$\frac{3000}{\text{Tensile strength}}$$

and so that the product

$$V\,.\,a\,.\,b=\frac{\text{Constant}}{\text{Tensile strength}^2}=\frac{114\times10^6\,d^2}{T^2}.$$

If the dimensions of a keyway are width=d, depth=c, and length=L, with a net length of traverse =l, where l=L−d, then

Cutting time=Number of strokes×time per stroke

$$=\frac{c\times10^3}{a}\times\frac{l\times10^3}{\text{r.p.m.}\times b}$$

$$=\frac{c\times l\times10^6}{a\times b\times\dfrac{12\times V}{\pi d}}=\frac{d\,.\,c\,.\,l\,.\times10^6}{3{\cdot}82\,V\,.\,a\,.\,b}$$

$$\text{or}\quad\frac{V\,.\,a\,.\,b}{10^6}=\frac{d\,.\,c\,.\,l}{3{\cdot}82\ \text{time}}\quad.\quad.\quad.\quad(1)$$

This expression is used to check the test data given in the following tables.

Table I and Fig. 1 give the performance data for a machine capable of using cutters up to ¾in. diameter, and indicate that for good finish the product $a\,.\,b$ is limited to 1000 d^2. Table II and Fig. 2 give a similar series of results obtained on a machine capable of using cutters up to 1¼in. diameter and indicate that for steel of 31·7 tons per square inch, $a\,.\,b$ is limited to 1200 d^2. In each of these two cases the machine is robust enough to drive the largest size cutter at its limit, but in Table III and Fig. 3 data are given for a nominal ¾in. machine, which, as seen from Fig. 3, cannot exceed the full capacity of a ⅝in. cutter and ¾in. cutters had to be run at reduced outputs because vibration of the machine itself took place before the limit of a ⅝in. cutter was reached. This limit for 38 tons per square inch steel was $a\,.\,b$=380. The effect of cutting other steels is shown in Table IV and Fig. 4 for high carbon steel of 46·3 tons per square inch, for which $a\,.\,b$ is limited to 800 d^2, with a limit in this material for the same machine as Table III of 300.

Summarising the above, it is seen that $a\,.\,b$=K d^2, where K=1000 for 38 tons per square inch steel, 1200 for 31·7 tons per square inch, and 800 for 46·3 tons per square inch, from which

$$K=\frac{3800}{\text{Tensile strength}}$$

From the expression (1) it is possible to arrive at

TABLE I.—¾in. *Key and Cotterway Machine ; Material Medium Carbon Steel, 2in. Diameter, 38 Tons per Square Inch ; Four Blade Cutters Lubricated with Cutting Compound (Soluble Oil in Water).*

Keyway dimensions. Width, d.	Depth, c.	Length, L.	Net length of traverse, l.	Cutter, r.p.m.	Nominal feed per stroke.	Strokes per minute.	Time to cut keyway.	Cutter speed, ft./min. V	$\frac{d.c.l.}{3{\cdot}82\times\text{time}}=\frac{V.a.b.}{10^6}$	Parameter, a.b.	Remarks.
Inch.	Inch.	Inches.	Inches.		inch.		Min. sec.				
1/16	1/16	2	1·69	920	0·006	11·6	5 45	75·3	0·0075	100	Good finish
1/16	1/16	2	1·69	920	0·006	19·0	3 50	75·3	0·0113	150	Rough
1/8	1/8	4	3·63	920	0·008	5·4	8 35	90·4	0·0156	172	Fair finish only
1/8	1/8	4	3·63	920	0·008	10·0	5 05	90·4	0·0263	297	Rough
1/8	1/4	4	3·50	510	0·010	10·0	3 10	66·7	0·0362	542	Rough
1/8	1/4	4	3·50	920	0·012	5·4	4 30	120·4	0·0255	211	Good finish
1/8	1/8	4	3·38	510	0·012	5·4	10 35	83·4	0·0327	392	Good finish
1/4	1/8	3	2·25	510	0·010	10	3 50	100	0·0432	432	Good finish
1/4	1/8	3	2·25	510	0·016	11·6	2 55	100	0·0568	568	Good finish
1/4	1/8	6¼	6·00	510	0·012	3·3	9 40	100	0·0457	457	Good finish

TABLE II.—1¼in. *Machine ; Material, Medium Steel, 31·7 Tons per Square Inch.*

Keyway dimensions. Width, d.	Depth, c.	Length, L.	Net length of traverse, l.	Cutter, r.p.m.	Nominal feed per stroke.	Strokes per minute.	Time to cut.	Cutter speed, ft./min., V.	$\frac{d.c.l.}{3{\cdot}82\times\text{time}}=\frac{V.a.b.}{10^6}$	a.b.	Remarks.
Inches.	Inches.	Inches.	Inches.		Inch.		Min. sec.				
1/4	1/4	1	0·75	690	0·004	23	1 08	45·2	0·0054	120	Finish good
1/4	1/4	4	3·75	690	0·004	0·6	3 15	45·2	0·0094	209	Rough finish
1/8	1/4	2	1·50	690	0·009	8·4	3 14	90·4	0·0152	168	Good finish
1/8	1/4	2	1·50	690	0·009	16·0	1 45	90·4	0·0281	310	Finish fair
1/8	1/4	8	7·50	690	0·009	3·0	8 50	90·4	0·0278	307	Finish fair
1/8	1/4	8	7·50	690	0·009	3·4	6 10	90·4	0·0398	440	Rough finish
1/8	1/8	3	2·25	400	0·009	12	2 35	78·6	0·0641	816	Finish fair
1/8	1/8	3	2·25	400	0·013	12	2 10	78·6	0·0764	972	Rough finish
1/8	1/8	6	5·25	400	0·006	4·9	8 45	78·6	0·0442	562	Good finish
1/8	1/8	6	5·25	400	0·009	4·9	6 00	78·6	0·0644	820	Fairly good finish
1/8	1/8	6	5·25	400	0·009	5·4	5 25	78·6	0·0714	908	Rough finish
1¼	1/8	4	2·75	240	0·013	9·8	4 00	76·7	0·1406	1832	Six blade cutters good finish
Cotterways.											
13/32	Through	2	4 13/32	4·0	690	0·009	4·0	28 00	74·0	0·0152	205	Good finish
1/4	2¼	2	1·50	690	0·009	16·0	5 30	90·4	0·0402	444	Rough finish
1/8	2½	3	2·25	400	0·013	10·0	6 47	78·6	0·0733	932	Rough finish
1¼	3⅜	3⅜	2·25	240	0·009	10·6	18 30	78·6	0·0771	981	Six blade cutters : good finish
1¼	3⅞	3⅜	2·25	240	0·018	10·6	9 30	78·6	0·1502	1910	Six blade cutters ; good finish
1¼	3⅞	3⅜	2·25	240	0·012	26	6 15	78·6	0·2282	2900	Six blade cutters ; poor finish

TABLE III.—¾in. *Keyway Machine ; Material, Medium Carbon Steel, 38 Tons per Square Inch ; all Cutters Four Edges.*

Keyway dimensions. Width, d.	Depth, c.	Length, L.	Net length of traverse, l.	Cutter, r.p.m.	Nominal feed per stroke.	Strokes per minute.	Time to cut.	Cutter speed ft./min. V	$\frac{d.c.l.}{3{\cdot}82\ t.}=\frac{V.a.b.}{10^6}$	a.b.	Remarks.
Inch.	Inches.	Inches.	Inches.		Inch.		Min. sec.				
1/4	1/8	4	3⅛	1200	0·004	5·84	5 00	78·6	0·00613	78	Good finish
1/16	1/16	2	1 1/16	1200	0·010	19·4	2 30	98	0·0173	176	Rough finish
1/16	5/32	4	3·69	700	0·006	5·84	5 00	57	0·0094	165	Rough finish
1/16	5/32	2	1·69	1500	0·012	11·54	1 45	123	0·0123	100	Good finish
1/8	1/16	2¼	1·88	1500	0·006	14·0	3 15	147·4	0·0106	72	Good finish
1/8	1/8	2	1·63	1200	0·008	11·54	3 30	117·9	0·0171	145	Good finish
1/8	1/16	4	3·63	1200	0·008	5·84	7 00	117·9	0·0095	81	Good finish
1/8	1/8	4	3·63	1500	0·008	11·54	3 15	147·4	0·0411	279	Rough finish
1/8	1/8	4	3·63	1500	0·012	5·84	4 30	147·4	0·0297	192	Fairly good finish
1/8	1/8	4	3·50	1092	0·014	5·84	5 35	143	0·0410	287	Rough finish
1/8	1/4	4	3·50	700	0·008	5·84	4 30	91·7	0·0255	277	Fairly good finish
1/8	1/16	4	3·38	450	0·004	3·3	17 00	73·6	0·0100	136	Good finish
1/8	1/16	4	3·38	700	0·012	5·84	3 40	115	0·0471	410	Rough finish
1/8	1/8	4	3·38	638	0·010	5·84	10 00	104·4	0·0346	331	Good finish
1/8	1/8	4	3·38	638	0·012	5·84	8 20	104·4	0·0415	397	Rough finish
1/4	1/8	3	2·25	638	0·004	20·2	4 10	125·3	0·0398	317	Good finish
1/4	1/8	3	2·25	493	0·006	20·2	2 50	96·8	0·0585	604	Rough finish
1/4	1/8	3	2·25	700	0·008	5·84	4 30	137·4	0·0368	268	Good finish
1/4	1/8	3	2·25	493	0·012	5·84	4 45	96·8	0·0349	360	Good finish
1/4	1/8	3	2·25	493	0·012	10·0	3 50	96·8	0·0432	447	Rough finish
Cotterways.											
1/4	2 1/16	4	3·75	1200	0·004	5·84	43 00	78·6	0·0059	75	Good finish
1/16	2 1/16	4	3·69	1200	0·006	5·84	30 00	98·0	0·0108	110	Good finish
1/16	2	2	1·69	1500	0·008	20·2	6 30	123	0·0213	173	Rough finish
1/8	2	4	3·63	1500	0·012	5·84	12 00	123	0·0297	241	Fair finish
1/8	2 1/16	4	3·63	1200	0·006	5·84	27 00	118	0·0136	115	Good finish
1/8	2	4	3·50	1092	0·010	5·84	16 50	143	0·0272	190	Good finish
1/8	2	4	3·50	1092	0·012	5·84	13 45	143	0·0333	233	Fairly good finish
1/8	2	4	3·50	700	0·012	5·84	12 30	91·7	0·0367	400	Rough finish
1/8	2 1/16	4	3·38	400	0·004	5·84	46 00	65·4	0·0124	189	Good finish
1/8	2	4	3·38	700	0·012	5·84	13 15	115	0·0418	364	Good finish
1/8	2	4	3·38	638	0·012	5·84	14 00	104·4	0·0395	378	Good finish
1/4	2	3	2·25	638	0·004	20·2	11 56	125·3	0·0370	296	Good finish

an equation for the minimum time for milling a keyway, thus

$$\text{Cutting time} = \frac{d \,.\, c \,.\, l \times 10^6}{3{\cdot}82\ \text{V} \,.\, a \,.\, b}$$

$$\text{and } a \,.\, b = \frac{3800}{\text{T}} \text{ and V} = \frac{3000}{\text{T}}$$

so that

$$\text{Cutting time} = \frac{c \,.\, l \,.\, \text{T}^2}{436\, d}$$

$$\text{or Time} = \frac{\text{M} \,.\, c \,.\, l}{d}$$

where M = 2·07 for 30 tons per sq. inch steel
3·0 for 36 ,, ,, ,,
4·0 for 42 ,, ,, ,,
6·0 for 51 ,, ,, ,,

This expression has been used to make a comparison with the published cutting times given in various makers' catalogues, as summarised in Table V. This shows a general agreement between these figures and the preceding argument, apart from a few unexplainable discrepancies due to lack of detail in the published data, and also shows the previously discussed interaction of the limit of the machine restricting performance on the largest size of keyways.

One important deduction can be made from this investigation. The product $a \,.\, b$ of depth of cut per stroke and traverse per revolution of the cutter being the criterion of performance, it does not seem necessary to provide a range of variables for each of these units, as is usual in keyway machines. On the contrary, the rate of traverse per revolution of the cutter could be kept constant and all adjustment of the parameter $a \,.\, b$ made by varying the depth of cut per stroke. This would overcome in a simple manner one of the difficulties of these machines, as approximately uniform speed of traverse is usually obtained by "correcting" a crank motion by interposing two offset crank discs with die block and slot along with a 2 to 1 reduction, such as is shown in Fig. 5. Uniform motion at one speed of traverse in inches per minute, a suitable value being 24in. per minute, could be obtained hydraulically by utilising a simple gear pump driven at constant speed from the first motion shaft of the machine. In this way a value of b, the traverse per revolution of cutter, would be obtained inversely proportion to cutter r.p.m. and as this latter,

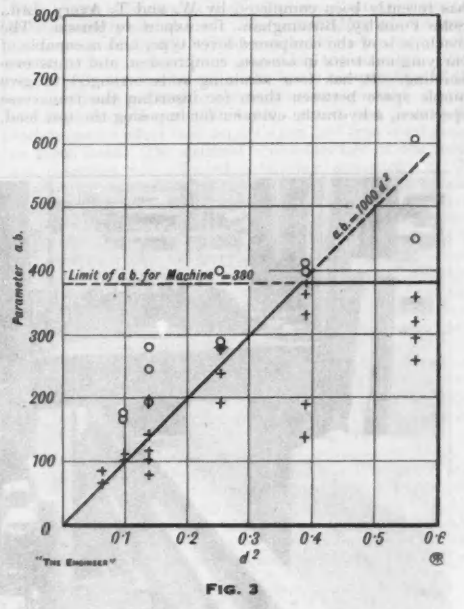


FIG. 3

(for desired constant cutting speed) is inversely proportional to d, the cutter diameter, b would be proportional to d, so that adjustment of the parameter $a \,.\, b$, through the medium of a, the depth of cut per

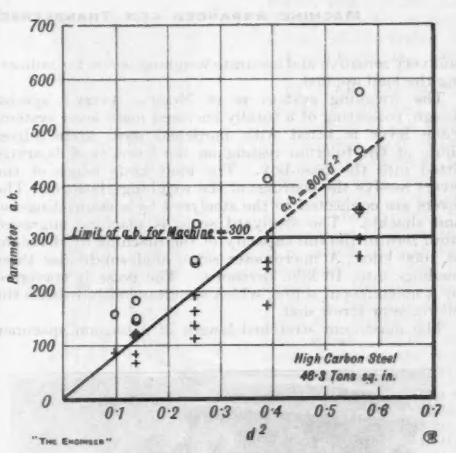


FIG. 4

stroke, would only need to vary as the cutter diameter, and inversely as the tensile strength of the material cut. This hydraulic traverse system would be simple and cheap, as no variable stroke pump is required, and

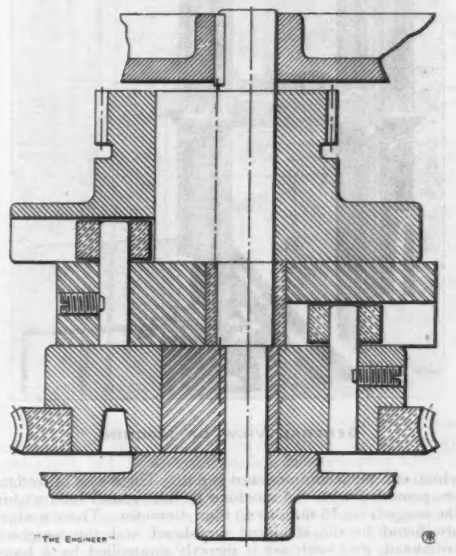


FIG. 5

uniform traverse motion would be secured to a better degree than is obtained by any "correction" of a crank motion.

TABLE IV.—*½in. Keyway Machine; Material, High-carbon Steel Normalised, 46·3 Tons per Square Inch.*

Keyway dimensions. Width, d.	Depth, c.	Length, L.	Net length of traverse, l.	Cutter, r.p.m.	Nominal feed per stroke.	Strokes per minute.	Time to cut,	Cutter speed, ft./min. V.	$\frac{d.c.l.}{3{\cdot}82\,t} = \frac{\text{V}.a.b.}{10^6}$.	a.b.	Remarks.
In.	Inches.	Inches.	Inches.		inch.		Min. sec.				
½	1/16	1½	1·13	1200	0·004	11·54	4 00	117·9	0·0052	44	Good finish
½	1/16	1½	1·13	1200	0·004	20·2	2 13	117·9	0·0094	80	Good finish
½	1/16	1½	1·13	1200	0·004	34·4	1 18	117·9	0·0160	136	Rough finish
½	½	4	3·63	1200	0·008	5·84	7 45	117·9	0·0172	146	Rough finish
½	½	4	3·63	1200	0·010	5·84	6·15	117·9	0·0214	181	Rough finish
½	½	4	3·50	1200	0·008	5·84	5 30	157·2	0·0208	133	Good finish
½	½	4	3·50	1200	0·004	10·0	5 35	157·2	0·0205	131	Good finish
½	½	4	3·50	1200	0·006	11·54	3 42	157·2	0·0310	197	Good finish
½	½	4	3·50	1200	0·008	11·54	2 50	157·2	0·0404	257	Finish fair
½	½	4½	3·63	700	0·010	5·84	4 00	91·7	0·0297	324	Rough finish
½	½	4	3·38	700	0·006	10·0	10 05	114·6	0·0343	299	Good finish
½	½	3	2·25	400	0·016	5·84	4 30	78·6	0·0368	469	Rough finish
½	½	3	2·25	400	0·006	11·54	3 40	78·6	0·0452	575	Rough finish
½	½	3½	2·38	700	0·008	10·0	4 45	137·4	0·0369	269	Good finish
½	½	3	2·25	400	0·012	5·84	6 00	78·6	0·0276	350	Fair finish
Cotterways.											
1/16	2	1½	1·56	1200	0·010	5·84	15 30	98·4	0·0082	84	Good finish
1/16	2	1½	1·56	700	0·012	5·84	14 10	57·4	0·0090	157	Rough finish
½	2	1½	1·13	1200	0·004	20·2	13 50	117·9	0·0080	68	Good finish
½	2	1½	1·13	1200	0·004	34·4	8 20	117·9	0·0133	113	Finish fair
½	2	1½	1·00	700	0·004	20·2	13 05	91·7	0·0100	109	Good finish
½	2	1½	1·00	700	0·006	20·2	8 43	91·7	0·0150	164	Good finish
½	2	1½	1·00	700	0·006	34·4	5 30	91·7	0·0238	260	Rough finish
½	2	2½	1·63	700	0·004	20·2	13 25	114·6	0·0199	174	Good finish
½	2	2½	1·63	700	0·006	20·2	9 00	114·6	0·0296	259	Good finish
½	2	2½	1·63	700	0·010	11·54	9 30	114·6	0·0281	245	Good finish
½	2	2½	1·63	700	0·008	20·2	5 40	114·6	0·0471	411	Rough finish
½	2	3	2·25	400	0·010	5·84	18 55	78·6	0·0234	297	Good finish

TABLE V.

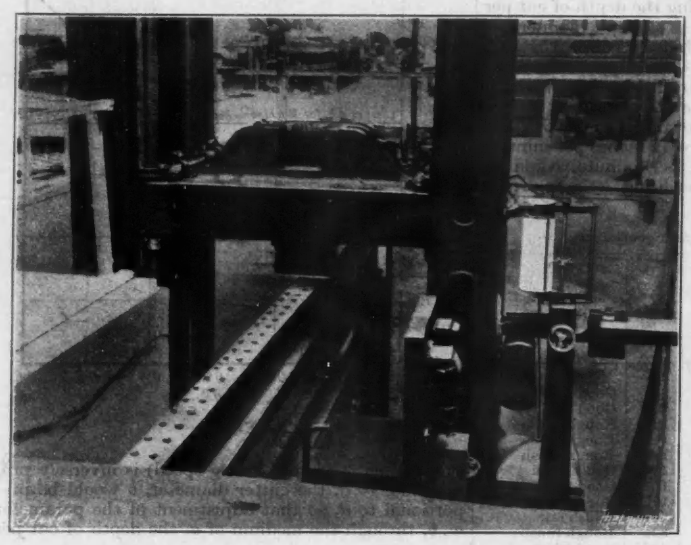
Keyway dimensions. Width, d.	Depth, c.	Length, L.	Net traverse, l.	Material.	Cutting time. Actual.	Cutting time. Calculated.	Catalogue.	Remarks.
Inch.	Inches.	Inches.	Inches.		Min. sec.	Min. sec.		
⅛	⅛	2½	2	Mild steel	3 00	4 08	Asquith	Four-blade cutters
⅛	5/32	2⅝	2	,,	3 00	4 08	,,	,, ,,
⅛	thro' 2	2¼	2	,,	17 00	16 36	,,	,, ,,
⅛	thro' 2	2½	2	,,	17 00	11 00	,,	,, ,,
⅛	⅛	4	3·63	Nickel steel 50 T	6 40	20 50	,,	,, ,,
¼	¼	4	3·50	Mild steel	3 00	3 37	,,	,, ,,
¼	¼	4	3·50	Carbon steel 45 T	3 42	8 08	,,	,, ,,
⅛	⅛	4	3·37	Mild steel	6 40	7 00	,,	,, ,,
¼	⅛	3	2·25	Carbon steel	3 40	5 15	,,	,, ,,
1/16	thro' 3	1½	1·44	Mild steel	27 00	14 15	,,	,, ,,
¼	thro' 2	1½	1·0	High-carbon steel	8 43	9 18	,,	,, ,,
⅛	thro' 2	2¼	1·63	,, ,,	9 00	12 08	,,	,, ,,
¼	thro' 2	3	2·25	,, ,,	18 55	14 00	,,	,, ,,
¼	thro' 3	3	2·25	Mild steel (?)	10 00	9 18	Smith and Coventry (1927), Ltd.	Four-blade cutters
⅛	thro' 2	2	1·50	,,	5 10	6 13	,,	,, ,,
⅛	thro' 1	1	0·75	,,	3 10	3 06	,,	,, ,,
1¼	⅛	4	2·75	,,	13 00	2 50	,,	Six-blade cutters, limited by machine
1	½	5	4·00	,,	14 00	4 08	,,	Four-blade cutters, limited by machine
¼	¼	6	5·25	,,	8 45	5 26	,,	Four-blade cutters
¼	⅛	3	2·25	,,	4 12	2 20	,,	,, ,,
⅛	⅛	8	7·50	,,	10 30	7 47	,,	,, ,,
⅛	⅛	2	1·50	,,	2 30	1 33	,,	,, ,,
¼	¼	4	3·75	,,	3 30	3 53	,,	,, ,,
¼	⅛	1	0·75	,,	0 45	0 47	,,	,, ,,
1	⅛	5¼	4·75	Mild steel (?)	2 52	3 40	Geo. Richards*	Cut by sinking to depth and then by one traverse stroke
1¼	⅛	6¼	5·00	,,	3 00	3 06	,,	,, ,,
⅛	5/32	1⅜	1·25	Mild steel (?)	1 30	1 06	Hurth	Two-blade cutters
⅛	5/32	2¾	2·25	,,	2 00	1 10	,,	,, ,,
1/16	5/16	5½	5·18	,,	2 30	3 35	,,	,, ,,
⅛	15/64	7½	6·88	,,	5 00	5 18	,,	,, ,,
1/16	7/32	1½	0·81	,,	1 00	0 32	,,	,, ,,
¼	¼	1½	0·75	,,	4 00	1 33	,,	,, ,,
⅛	15/64	2⅜	1·63	,,	1 00	1 03	,,	,, ,,
¼	15/64	5½	5·00	,,	2 12	3 12	,,	,, ,,
1/16	⅛	2	1·06	,,	2 00	1 10	,,	,, ,,
1	¼	3½	2·50	,,	1 42	1 18	,,	,, ,,
1	⅜	5½	4·75	,,	3 30	3 42	,,	,, ,,
1¼	11/32	3½	2·00	,,	1 30	1 18	,,	,, ,,
1¼	⅜	3 3/16	2·18	,,	3 30	3 00	,,	,, ,,
1¼	⅜	6	4·75	,,	3 30	3 00	,,	,, ,,
1 7/16	7/16	3½	1·69	,,	2 00	1 06	,,	,, ,,
1 7/16	7/16	6½	4·81	,,	4 00	3 00	,,	,, ,,
1½	½	4½	3·25	,,	4 30	2 12	,,	Two-blade cutters, limited by machine
1 9/16	19/32	8	6·43	,,	10 00	5 06	,,	Two-blade cutters, limited by machine

* See *British Machine Tool Engineering*, May–June, 1933, page 325.

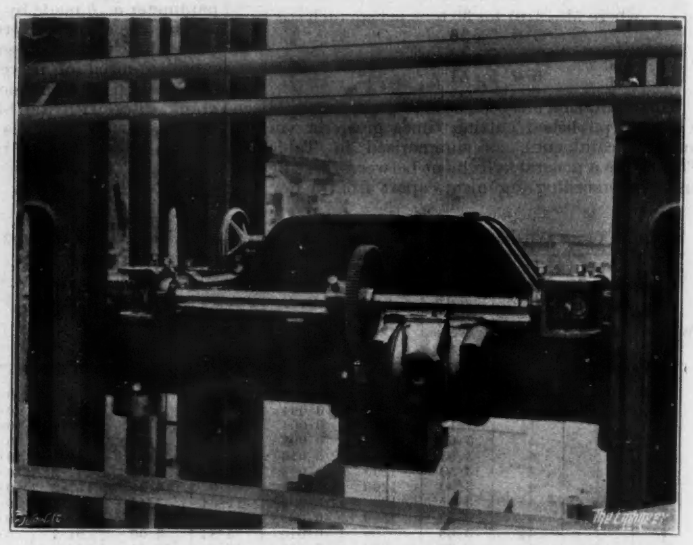
IT is announced that the Mid-Cheshire Regional Planning Committee has decided to establish landing grounds for aeroplanes at Crewe, Nantwich, Congleton, and Macclesfield.

Compound Lever Testing Machine for Russia.

THE 180,000 kilo. testing machine illustrated herewith has recently been completed by W. and T. Avery, Ltd., Soho Foundry, Birmingham, for export to Russia. The machine is of the compound lever type, and is capable of carrying out tests in tension, compression, and transverse bending. It has four straining rods arranged to give ample space between them for inserting the transverse specimen, a hydraulic cylinder for imposing the test load.



MACHINE ARRANGED FOR TRANSVERSE BENDING TEST

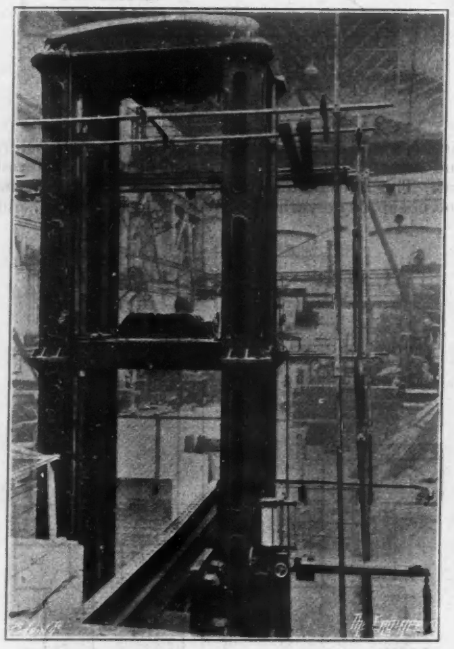


THE STRAINING CROSSHEAD

and very sensitive and accurate weighing levers for indicating the load applied.

The weighing system is of Messrs. Avery's special design, consisting of a totally enclosed main lever system. Each lever is fitted with hardened steel knife edges, those at the fulcrum resting on hardened steel bearings fitted into the base-box. The load knife edges of the levers receive the bearings of the weighing platform. The levers are connected to the steelyard by a connecting-rod and shackle. The steelyard scale is machine engraved from zero to the full capacity of the machine by divisions of 1000 kilos. A micrometer screw dial subdivides these readings into 10 kilo. divisions. The poise is traversed by a machine-cut screw, which simultaneously rotates the micrometer screw dial.

The maximum stretched length of a tension specimen

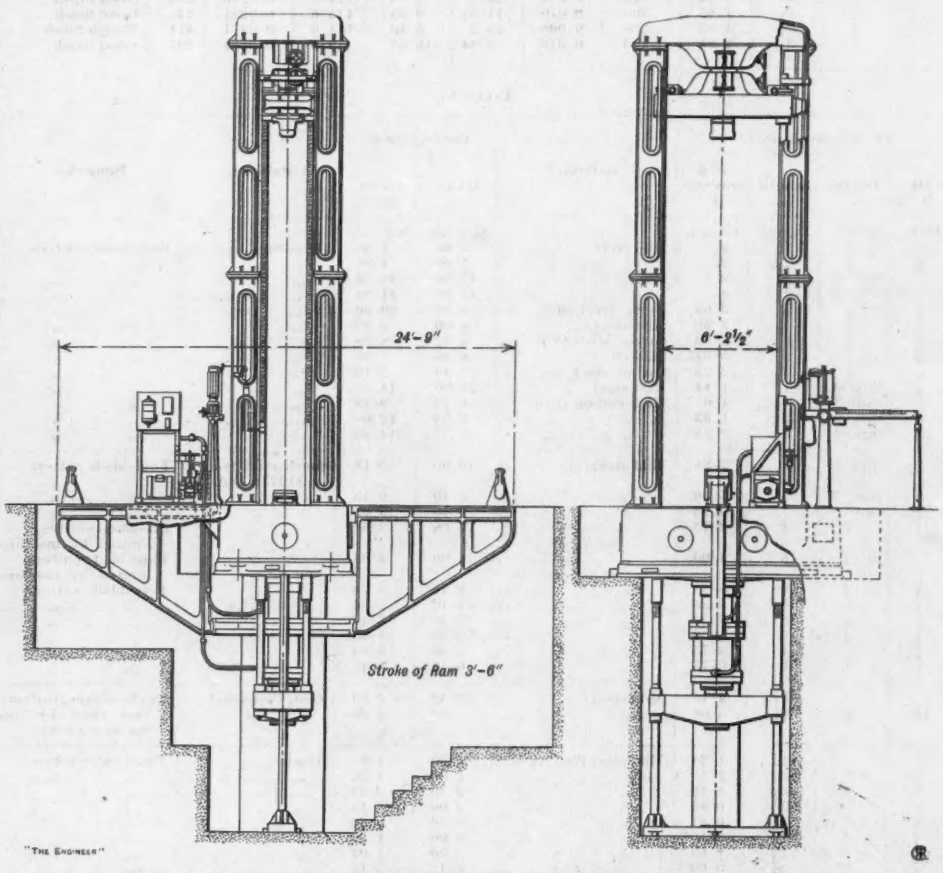


GENERAL VIEW OF MACHINE

which can be accommodated is 6 m. Three sets of wedges are provided with the machine to take round bars within the range from 15 mm. to 40 mm. diameter. These wedges are fitted in the straining crosshead and the weighing crosshead, and each set is directly controlled by a hand wheel operating a machine-cut pinion on a rack. The two wedges in each holder are also interlocked in such a way that they move together. The straining crosshead can be adjusted on its four screws to within 75 mm. of the weighing crosshead, thus enabling very short tensile specimens (say, down to 50 mm. gauge points) to be tested. Limit switches are provided to prevent the crosshead over-running in either direction. The four rods are cut with a square thread and are connected to the straining crosshead by means of phosphor-bronze nuts.

Compression tests are carried out by placing the specimen between the straining crosshead and the compression platen on the surface of the weighing platform. A maximum length of 6 m. can be accommodated. A compression platen suitable for specimens up to 380 mm. square is provided for compression tests, and rests upon the surface of the weighing platform. This platen consists of a bearing block with a spherical seat to carry the platen block, which has a spherical under-surface. The sphere is generated from the centre point of the compression face of the platen block. The block is square and is provided with set screws on the corners to hold it in position while the specimen is being set up. Diagonal lines and rings are engraved on the face of the block. For transverse tests bending dogs 380 mm. wide and 610 mm. high are provided. The span is adjustable from 1200 mm. to 7000 mm.

The strain is applied to the specimen through the medium of the hydraulic cylinder and ram, the operating fluid being mineral oil. The ram is a close-grained iron casting with a ground surface and is connected to a crosshead which receives the four straining rods of the machine. The hydraulic pressure is retained between the gland and the ram by "U" leathers and by cup leathers in the ram itself. The cylinder and ram are designed to give a quick return after the test with a small expenditure of oil. The hydraulic supply to the cylinder for straining and returning is controlled by a hand wheel incorporated in the pumping unit. A feature of this hand wheel control is a fine speed regulation in either direction. The pumping set is placed in such a position that the operator has control of both the pump hand wheel and the hand wheel for propelling the poise along the steelyard. The maximum straining speed obtainable with the pump motor running at approximately 710 r.p.m. is 50 mm. per minute, and maximum return speed in the upward direction is 450 mm. per minute.



ARRANGEMENT OF 180,000 KILO. TESTING MACHINE

Geophysical Survey in the South Wales Coalfield.*

TRIALS of geo-electric methods to test the possibility of their use in detecting underground water in mining areas were arranged in South Wales under the supervision of Professor A. H. Cox (Professor of Geology in the University College, South Wales) under the auspices of the Geophysical Committee of the Department of Scientific and Industrial Research.

It was hoped that by carrying out the trials in a coalfield area they might throw light on the possibilities of the application of geophysical prospecting methods to the detection and survey of waterlogged areas in abandoned coal workings. Such areas are common in most of the older coalfields, and since their exact extents are often unknown owing to lack of plans of the early workings, they are often a source of grave danger, and many serious inrushes into newer workings have occurred. It is therefore highly desirable that some method should be elaborated for detecting the boundaries of such flooded areas. Unfortunately, these first trials have not proved successful in detecting the presence and extent of waterlogged areas, even in known and selected positions, and it would be premature at the present stage to attempt to apply them to unknown areas. Nevertheless, in view of the importance of the problem and the very small amount of geo-electrical work carried out in this country, the Department decided that the details of methods and

* "Report on Certain Trials of Geo-Electric Methods in South Wales, with Special Reference to the Possibility of their Use in Detecting Underground Water in Mining Areas," published by H.M. Stationery Office, price 2s. 6d. net.

of the results obtained ought to be made available to those interested. A report has accordingly been published by H.M. Stationery Office.

The report points out that hardly anywhere have geo-electrical methods been previously applied directly to the problems of coal measure geology. It was considered that the methods should be tested under the conditions prevailing in Great Britain, in order to obtain information as to the resistivity of various types of strata in the field, to test the possibility of mapping outcrops concealed by drift and other superficial deposits, and of determining the depth at which changes in the nature of the strata occurred.

The report outlines the difficulties that might be expected owing to complications in the geological structure. For this reason it was obviously desirable to carry out the first test in areas where the fullest possible information was already available. The apparatus and the methods employed are indicated briefly. The primary method was the Ratiometer or A.C. Potential Ratio method, devised by Mr. Broughton Edge and the late Dr. Bieler, which had proved very successful in the investigations of the Imperial Geophysical Expedition in Australia. Other methods employed depended upon the use of the Megger earth-tester and the D.C. Potentiometer. These shallow-depth resistivity methods were used to evaluate the effects of superficial deposits and of changes in strata near the surface, and so to afford a check on the ratiometer method in which a deeper current penetration should be possible.

The depth-resistivity methods, employing the Megger earth-tester and the D.C. Potentiometer, were found to give fairly reliable information of strata changes down to 100ft. These methods proved particularly valuable for the determination of the positions and nature of outcrops concealed beneath superficial deposits. At several localities it was found possible to delineate such concealed outcrops in places where the presence of the particular bands could not be deduced from the information already known from plans or maps. In fact, wherever the vertical succession of the strata was not previously known in detail from actual observations, the electrical traverses yielded further information regarding the rock sequence, even in the cases of traverses chosen for their apparent geological simplicity. It appears probable that the application of such methods may prove of great value in the geological mapping of drift-covered areas, especially in cases where it is necessary to obtain precise information for engineering, mining, or water-supply purposes.

The A.C. Potential Ratiometer, with its deeper current penetration, was, in places, influenced by the effects of deeper structures, but, as a general rule, the effects of such deeper structures were largely masked by effects due to variations in the strata at or near the surface. The presence of underground water in old workings was not detected with any certainty except possibly in the case of some of the shallower workings. In a number of tests, however, deeper structures evidently contributed to the observed effects. In certain tests there appeared to be repeated coincidences between the potential distribution and the positions of boundaries or coal pillars in the workings, but in general, it was difficult to separate the deeper effects from those which were clearly due to surface or shallow-depth effects. Resistivities of the Coal Measure strata were themselves comparatively low, and the resistivity ratio to the underground water was not sufficiently marked to outweigh more superficial effects. Tests underground proved that in some cases the possible effects of underground water could readily be shielded from surface observations.

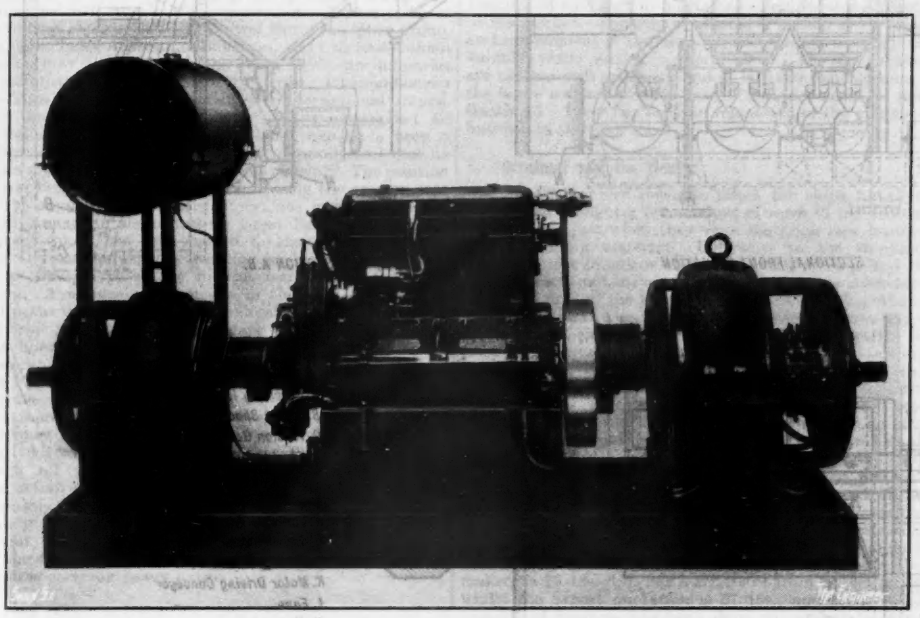
It appears that a method of integrating the results from a deep-current penetration method with those from a shallow-depth resistivity method, and so allowing for a quantitative, instead of a merely qualitative allowance for purely surface effects, is a necessity for further attack on the problem of the detection of watered areas.

THE London Passenger Transport Board is continuing the policy of installing engines of the compression-ignition type in its buses and Green Line coaches. It owns 5500 buses, and of these 850 are so equipped.

Engine-Driven Generating Sets for Submarine Cable Service.

THE Parsons Oil Engine Company, Ltd., Southampton, has recently completed an order for five sets of special generating plants for Standard Telephones and Cables, one of which we illustrate herewith.

The equipments have a number of points of interest. It will be seen from the illustration that the engine is coupled to two dynamos, one at each end, and the couplings are of special detachable pin type, which can be drawn out of engagement by hand at any time, leaving only one dynamo coupled. The engine-starting handle is transferred to the dynamo ends of the plant, and right and left handles are provided so that either dynamo can be started up independently of the other. The starting dogs are efficiently guarded, as are the couplings.

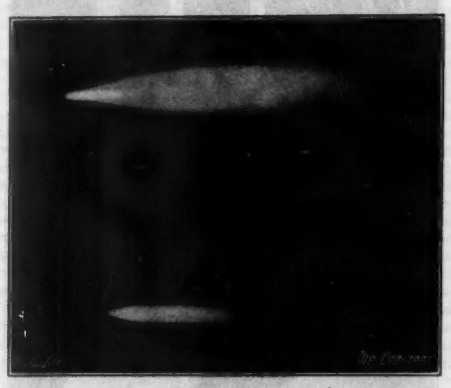


GENERATING SET FOR SUBMARINE CABLE SERVICE

The plants in question are destined for the Australian-Tasmanian submarine cable service. The larger set comprises a Parsons 25 h.p. stationary petrol engine coupled to E.C.C. dynamos, No. 1 being 240 ampères, 20–35 volts, and No. 2, 15 ampères, 120–180 volts. The plant is also fitted with a fuel tank to hold enough fuel for a 12-hour run. There are three engines of this size, one being destined as a single plant for one station, and the other two for another station. In addition to the above three sets, two further equipments of similar type, comprise the well-known Parsons 10–20 h.p. "D 4" engine, direct coupled to very similar dynamos, the outputs being 65 ampères, 20–35 volts, and 50 ampères, 120–180 volts respectively.

A New Welding Process.

As long ago as 1903 two of the pioneers of oxy-acetylene welding, Fouche and Picard, recognised that a mixture of coal gas, acetylene, and oxygen had definite advantages over a mixture of acetylene and oxygen only. It is generally accepted that the inner cone of an oxy-acetylene flame, which is the part of the flame used for welding, has a temperature of between 3300 deg. to 3500 deg. Cent., and that it is unnecessarily high. The skill of the operator is usually able to overcome this disadvantage, but it is recognised that great benefit would accrue from the use of a similar flame with a somewhat lower temperature. The reason for this fact becomes apparent when it is pointed out that the melting point of iron is approximately 1500 deg. Cent., and that it boils at temperature of about 2450 deg. It has been found that by mixing a certain proportion of coal gas with acetylene, before the acetylene is in turn mixed with oxygen, the temperature of the flame can be reduced to about 2600 deg. Allowing for heat losses that occur through radiation, the flame temperature drops below the boiling point of iron, but is still well above the melting point.



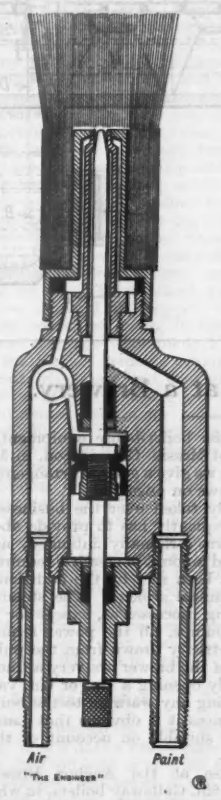
OXY-ACETYLENE COAL-GAS AND ORDINARY OXY-ACETYLENE FLAMES

Fouche and Picard, although they saw both the problem and its solution, did not succeed in devising a satisfactory mixer for acetylene and coal gas. Barimar, Ltd., welding engineers, of London, have recently installed in their works a mixer for acetylene and coal gas, which, we are informed, is giving very satisfactory results. This mixer is known as the "Sopromo," and is patented in this country and abroad. The outstanding advantage of the process is stated to be the remarkable purity of the weld, which is achieved without impairing the strength. This result is due to the fact that the lower temperature of the welding flame reduces to a minimum the amount of oxide absorbed into the welded metal, and it also avoids the carbonisation effect that occurs when cast iron is subjected to great heat. The original characteristics of the metal are therefore not affected. Another advantage of the lower temperature is that the area of the casting subjected to great heat is localised, and, consequently, the degree of expansion and contraction that occurs is minimised. In the oxy-acetylene flame, an excess of oxygen has to be used in order to carry along the acetylene. Such excess is not necessary with the "Sopromo" mixture, and the flame is consequently softer. No bubbling therefore occurs in the weld, and a much closer grain in the metal is obtained. The comparatively soft flame also spreads out over the metal, keeping the air away from it, and reducing still further the risk of oxidisation. It is emphasised that while it is possible that in time welding by the "Sopromo" method will be more rapid than by oxy-acetylene, the great merit of the new process is the remarkable purity and strength of the weld.

The accompanying engraving is reproduced from a photograph taken recently in the Barimar Welding Works to illustrate the difference in appearance between the Barimar-Sopromo oxy-acetylene coal-gas flame—at the top—and the ordinary oxy-acetylene flame—at the bottom. It shows that not only is the outer cone of the "Sopromo" flame larger, but it is also much "softer."

A Pneumatic Paint Brush.

A NEW model of pneumatic paint brush, which has recently been brought out by Bromak Pneumatic Paint Brush, Ltd., of 38, King William-street, London, E.C.4, is illustrated by the accompanying drawing.

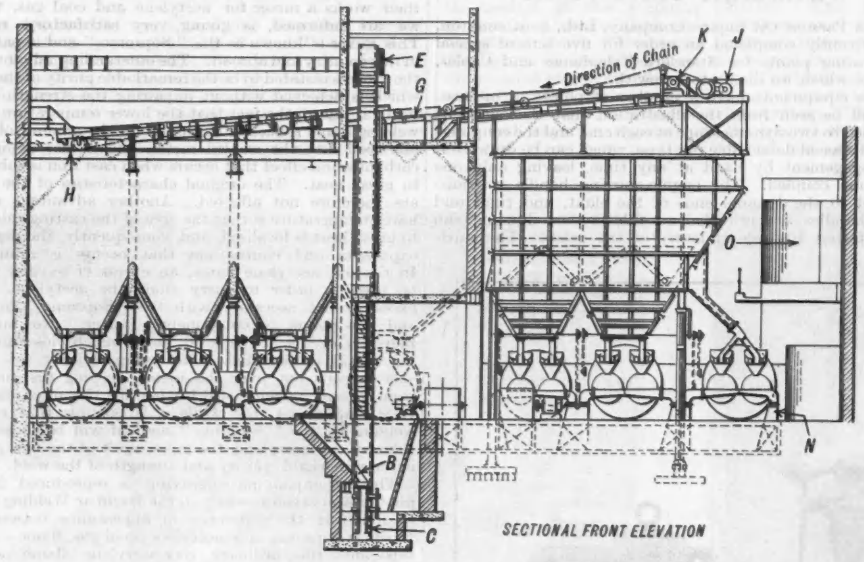


PNEUMATIC PAINT BRUSH

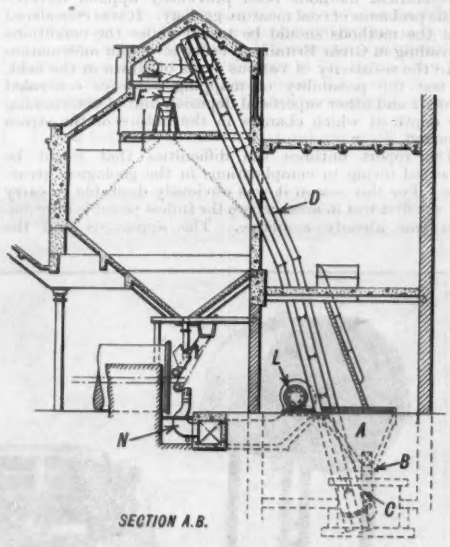
In these brushes the paint is injected into the interior of the bunch of bristles and works its way outwards as the brush is used just like an ordinary painter's tool. They have the advantages, however, that it is unnecessary to stop occasionally to dip the brush in the paint pot, while, as the paint comes from the inside, it does not splash about and leave drips on the floor. The system has the merit common to all brush work of rubbing the paint in and getting a good key with the surface being treated. The brush, which only weighs 4½ oz., is supplied with paint through one hose pipe and with compressed air at about 50 lb. per square inch by another. The air supply is controlled by a button in the handle, which is only operated when more paint is required. The stock of paint is held in a closed container, and is forced up to the brush by the air pressure. The paint is not tipped out of the can in which it is bought, but the whole can is placed in the container. It is consequently a simple matter to change from one colour to another, as the container need not be cleaned and it only remains to flush out the paint pipe, &c. Different bristle bunches can, of course, be fitted to the tool according to the class of work in hand. Three of these units are readily operated by a small air compressor requiring only 1½ h.p. and using about a gallon of petrol a day.

THE shareholders of the International Nickel Company of Canada, Ltd., have received from the company's president, Mr. Robert C. Stanley, the following letter:—"Until the public at large realises that there has been a significant change in the world nickel industry during the last fifteen years, we may continue to hear the repeated charge that your company is trafficking in a war material. The Alloy Age had its inception in the World War, and thus nickel, as a useful alloying element, became associated in the public mind with munitions. With the passing of years this Alloy Age has become linked with the progress which is being made in transportation, communication, and industry at large, and nickel continues in its *rôle* as one of the most useful of the alloying elements. The result is that more nickel is currently going into the numerous fields of peacetime activities than ever went into the world's battlefields. Every person who has expended thought, energy, or money in the development of nickel has cause for pride in the record which your company is making in a world at peace."

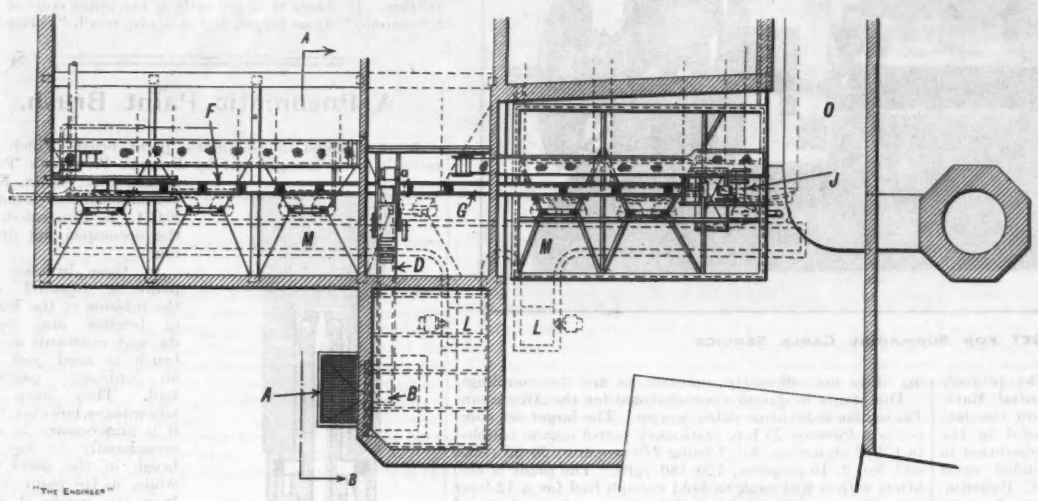
BOILER-HOUSE EQUIPMENT AT A BREWERY



SECTIONAL FRONT ELEVATION



SECTION A.B.



A. Receiving Hopper
B. Outlet Shoot
C. Tension Gear
D. Elevator
E. Driving Gear
F. Conveyor to Existing Storage Bunkers
G. Conveyor Serving New Bunkers
H. Tension Gear
J. Driving Gear
K. Motor Driving Conveyor
L. Fans
M. Main Air Duct
N. Branch Ducts to Stokers
O. Economiser

The Boilers at a Brewery.

A TYPICAL example of the boiler-house equipment at a modern brewery is that of Messrs. Charrington, in Mile End-road, London, of which we give a general arrangement above and some interior views on page 220.

This brewery has recently taken over the business of Hoare's brewery, and consequently has to provide about double the output that was originally intended, and, naturally, a greatly increased amount of steam is required; but this extra demand has been met by the addition of only one boiler and mechanical stokers. The steam is required entirely for brewing processes as, except for the driving of the Weir feed pumps, all the power requirements are provided by electricity drawn from the public mains. And the demands of the brewer are very arduous, as he thinks nothing of fully opening a 4in. or 6in. valve quite suddenly without giving any warning to the boiler-house. In these circumstances it is obvious that Lancashire boilers are the most suitable on account of their great heat-storage capacity.

The original boiler-house at the Anchor Brewery contained four 30ft. by 8ft. 6in. Galloway boilers, to which there were subsequently added another 8ft. 6in. boiler and a 30ft. by 9ft. 3in. Thompson boiler. On the amalgamation of the two breweries another 9ft. 3in. Thompson boiler was added, together with an economiser, the mechanical stokers, and a coal-handling plant. There are thus seven boilers in all, and it was anticipated that six would be required to carry the normal load, with one laid off for cleaning; but it has been found that with the new equipment five boilers are sufficient, and this is in spite of the fact that within the space of half an hour the demand for steam may be trebled or decreased by the same amount.

The design and construction of the Galloway and Thompson boilers are so familiar to our readers that it is unnecessary to enlarge upon them here, as is also that of the Green's economiser. The latter, however, is peculiar in that it is perched up above the boilers, to save space, as shown in the drawing, and has 360 tubes 11ft. 6in. long.

Average working figures are as follows:—

Steam pressure, per sq. in.		100 lb.
Feed temperature:	To economiser	125 deg. Fah.
	To boiler	240 deg. Fah.
Draught in main flue		−0·5in. w.g.
Suction over fires		−0·28in. w.g.
Forced draught		+2in. w.g.

It will be noted that the inlet temperature to the economiser is rather low, in spite of the fact that all the steam returns as condensate. This is accounted for by the fact that the present feed tank is rather small and sudden rushes of returns overflow to waste, but have to be subsequently replaced by cold make-up water. The average load on the boilers is in the neighbourhood of 60,000 lb. per hour, and, in the circumstances, it is noteworthy that a boiler efficiency of 76 per cent. is obtained.

The mechanical stokers and the coal-handling plant were supplied by Ed. Bennis and Co., of Little Hulton, Bolton, the firm which has recently been enlarged and renamed the Bennis Combustion Company.

The stokers are of the air-draught type, which was described in THE ENGINEER of June 9th, 1933. In this

FRONTS OF GALLOWAY-BENNIS BOILERS

stoker, it will be remembered, the steam jets of the original Bennis stoker, which were used to force air into the troughs below the fire-bars, are now replaced by a fan blowing air into ducts in the floor and reaching up across the boiler front. This ducting is plainly shown in the engravings, and does not interfere with hand firing should that have to be resorted to in a case of emergency. The air is supplied by either one of two electrically driven Howden fans. A secondary supply of air is provided at the front of the furnace, and is controlled by a small hand damper. It passes between the stoker front and the furnace-protection plates, and cools them in its passage. This arrangement has the advantage that the fireman is not tempted to open the steam jet valve fully, as used to be the case, and leave it so to the great waste of steam.

The fuel used is generally Northumberland singles, having a calorific value of about 12,000 B.Th.U. per lb., and is burned at the rate of about 40 lb. per square foot of grate area, but the rate can be increased to over 50 lb. if required, and then the whole load can be carried by only four boilers. The evaporation obtained is about 8·3 lb. of water (actual), or 9·3 lb. from and at 212 deg. Fah. per lb. of coal.

Above the boilers there are bunkers having a capacity of 800 tons of coal from which the coal gravitates to the stoker hoppers. These bunkers are filled by a bucket elevator and a scraper conveyor, the latter being illustrated in our engravings. The elevator is 14in. wide by 67ft. between centres, and is capable of dealing with 35 tons of coal per hour. It is driven by an 8 h.p. motor. It delivers the coal at about the centre of the length of the conveyor, which is of the U-link scraper type, and is driven by a 6 h.p. motor. The chain always travels in one direction, and when the bunkers on the left are to be supplied the coal is fed into the trough carrying the top strand of the conveyor chain. When the bunkers on the right are to be filled the coal is dropped through on to a lower trough where the returning chain runs.

An elaborate set of recording instruments has been supplied by James Gordon and Co., of Kingsway, and Messrs. Negretti and Zambra, and the instrument board is shown in one of our illustrations. There are a "Duplex" type Mono recorder for recording CO_2 and CO plus H_2, and a "Simplex" type Mono for CO_2 only. These instruments are connected through a manifold with each of the seven boilers and with a point in the main flue, so that a thorough check can be kept on combustion throughout the plant. There are also recorders for the steam pressure, the temperature of the feed in and out of the economiser, and the temperature of the feed water.

The chimney is of brick and is 180ft. high.

LAUNCHES AND TRIAL TRIPS.

ARBROATH, motor coaster vessel; built by Caledon Shipbuilding and Engineering Company, Ltd., Dundee, to the order of the Dundee, Perth and London Shipping Company, Ltd.; dimensions, 165ft. by 30ft. by 14ft.; to carry cargo. Diesel engines of Atlas type; constructed by British Auxiliaries, Ltd.; launch, August 14th.

STIRLING CASTLE, motor liner; built by Harland and Wolff, Ltd., Belfast, to the order of the Union-Castle Mail Steamship Company, Ltd.; dimensions, 725ft. by 82ft.; gross tonnage, 25,000 tons (approximately); to carry passengers and cargo. Oil engines of Harland and B. and W. type, ten cylinders, 660 mm. diameter, and piston stroke of 1500 mm.; constructed by the builders; launch, August 15th.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The International Steel Trade.

The Continental iron and steel markets have shown a distinct improvement during the past month, which is largely due to buyers' anticipating a rise in prices owing to the agreement between the British and Continental steel makers and the adherence of the Polish works to the Continental Steel Cartel. It cannot be denied that the Cartel has greatly strengthened its position, and there are now few important Continental industries left outside the organisation. Latterly, there have been reports that the Central European Steel group, which includes Austrian, Hungarian, and Czechoslovakian works, may also join with the other European industries in submitting to the control of the Cartel. These industries are already members of some of the international groups, but the Hungarian works have always maintained an independent attitude and for a long time have been a thorn in the flesh of the other Continental steel makers when attractive export business was offering. The position of the Belgian steel works which, during the greater part of the summer was unsatisfactory, has improved, and a good tonnage of the orders for Great Britain against the current quota has been passed to them by the Cartel. The German industry is working at high pressure, and its production is at the highest rate known for some years. A noticeable expansion in German steel exports has occurred lately, but a considerable proportion of the material sent abroad represents barter transactions. The home demand, however, is active largely owing to State and municipal undertakings which are in progress. The French steel works are fairly well supplied with orders, but the home trade lately has shown signs of declining and there has not been a corresponding improvement in export business. The slowness with which trade with nearly all overseas markets develops is one of the difficulties which all steel-producing countries are experiencing. The activity of the Japanese in foreign markets is being anxiously followed. Lately it is reported that the Japanese have made great efforts to secure a large share of the Indian market for small sections, and that they have obtained a fair amount of business by quoting cheaply for sizes carrying heavy extras.

Pig Iron.

Firm conditions continue to characterise the pig iron market, and considering the time of year the volume of business is encouraging. Although most of the consuming industries on the North-East Coast were closed down last week for the annual holidays, a fair number of transactions in pig iron were reported. Consumers appear anxious to cover their needs until the end of the year at least; but, on the other hand, makers are not keen on accepting far forward contracts. Makers' stocks have been reduced to rather slender proportions, and the whole of the make seems to be passing into consumption. Suspensions of delivery, therefore, to the local users, owing to the holidays, were welcomed by the producers, as they added a little to the pig iron in hand. The interest shown in the market this week indicates that there is not likely to be any fall in the demand, and fresh talk is heard of additions to the number of furnaces now producing foundry iron. Export business remains dull, and in the existing conditions producers are by no means inclined to accept the unattractive prices offered by overseas buyers. In the Midland district new business is not so active as earlier in the month, but the position is sound enough, since most of the big consumers have covered their forward requirements, and specifications against these contracts are reaching the works with regularity. In fact, deliveries in August in spite of the holidays are said to be equal to those in July. No alteration is expected in the price of Midland irons until the autumn, but, nevertheless, the result of the forthcoming meeting of the Central Pig Iron Producers' Association will be awaited with interest. Quotations for foundry iron have remained unaltered for about eighteen months at 67s. 6d. for No. 3 Northamptonshire and 71s. for Derbyshire, Lincolnshire and Staffordshire, but large consumers are given a rebate. Some decline in deliveries is reported in the Lancashire district as a result of holiday stoppages, but the position otherwise is unchanged. Owing to the number of forward bookings, important new transactions have been scarce, but the producers in every instance are carrying good order books and are assured of full production for some time. Business in hematite has been rather on the quiet side, since the advance in prices, but specifications continue to reach the works on a satisfactory scale.

The North-East Coast and Yorkshire.

The resumption of work after the local holidays on the North-East Coast was made in unusually favourable circumstances. Nearly every department of the works is operating at a high rate, and some makers are finding it difficult to keep abreast of their delivery times. The only disappointing feature of the market is the failure of the export demand materially to increase. Some slight broadening has been noticed in overseas requirements of finished materials, but this has not reached expectations. The home demand, however, seems to be increasing rather than declining, and it is anticipated that the steel makers on the North-East Coast will shortly be putting fresh plant into operation. The demand for billets is unabated, and consumers complain that some suppliers are falling behind with deliveries. In fact, it is suggested that there is a possibility of supplies being short during the next few months now that the imports of Continental material are rigidly curtailed. On this coast practically all the works producing semi-finished steel are operating at capacity. The structural engineers also are busy, and their requirements absorb a heavy tonnage of structural steel. This is, in fact, the busiest department, but there has been an encouraging broadening in the demand for special steels, to the production of which some works are paying special attention. The position with regard to shipbuilding material is not so good, although deliveries have improved lately as a result of the recent orders taken by the shipyards. The mills producing railway material also might be busier. With the end of the holidays business in the Yorkshire steel market is becoming increasingly active. The demand for basic steel, which relaxed somewhat in the first part of August, has again strengthened, and for basic billets is particularly vigorous, whilst business in acid carbon billets has again become a feature of the market. Sheffield producers of special steels report an improvement in the demand, and there is a steady and valuable trade passing in aircraft steel. The sheet makers are not too well occupied, and of late the requirements of the home market for this class of material seem to have slackened. There has been no relaxation in the volume of business in stainless steels.

Scotland and the North.

The orders recently taken for ships by Clyde yards have brought a fair amount of work to the Scottish steel makers just when they were requiring new business in shipbuilding material. Deliveries to the shipyards have been declining for the past month or two, and the new contracts and the expectations of others to come have greatly improved the tone of the market. During August about a dozen vessels have been ordered from Clyde builders, but some of these have been small craft. All the Scottish steel makers, however, are in a good position and can look forward to maintaining the present high rate of delivery until the end of the year. Some irregularity in working is said to exist in the constructional steel industry, but most of the big firms are employed on large contracts, and specifications for structural material are reaching the steel works at a satisfactory rate. The re-rolling works are in a better position than for some years; many of them are working full time and all are meeting with a stream of new orders. This branch of the trade is now experiencing the full benefit of protection, as the stocks of Continental material in Scotland have been largely absorbed. The quotation of the associated makers is £8 12s. d/d, less a rebate of from 2s. 6d. to 5s., whilst the export quotation is £7 10s., and lately a fair amount of business has been done on overseas account. Only a moderate amount of activity is passing in the Lancashire steel market, as, although the holidays are nearly over, business has not yet become normal. New business in the heavier descriptions of steel is rather quiet, particularly in the case of heavy plates, including boiler and ship plates. On the other hand, the demand for the lighter kinds has been steady. The structural engineers continue to take good deliveries of steel, but new business from this industry has been rather disappointing during the past week or two. There has been an improvement lately in the demand for bright steel bars, whilst the nut and bolt makers are well employed and are taking considerable quantities of both iron and steel bars. In the Barrow district the works have well-filled order books, and are producing good quantities of billets, bars, rails, and strip.

The Midlands and South Wales.

Considering that the industry is passing through the quietest trading period of the year, the condition of the Midland steel markets exceeds expectations entertained earlier in the season. A noticeable feature of the market is the strong demand for heavy steel joists and sections. Business in this material has been active for many weeks, and the demand shows no signs of declining. In contrast, the market requirements of smaller sections is not on such a good scale as might be expected, although a fairly substantial tonnage is passing into consumption. The constructional engineers in the Midlands are busy on some important contracts, and have a considerable amount of fresh work in view. Those firms which have held aloof from the Structural Engineers' Association, and are therefore not affiliated to the British Iron and Steel Federation, have to pay 30s. per ton more for their material than the associated firms. They are few in number, however, and, according to report, have covered their requirements for some time to come. The re-rolling industry is enjoying a spell of activity, and although there has been a certain amount of business done recently in Continental material of the sort produced by the re-rollers, this does not appear to have had any influence upon the demand from home users. Naturally, as a result of the Anglo-Continental Agreement, the tonnages available were small. Business in Continental merchant bars was transacted on the basis of £7 5s., whilst joists, B.S., were quoted at £7 8s. Some disappointment was expressed by consumers that larger quantities were not obtainable. The market for black sheets seems rather quiet, in view of the busy conditions ruling in other departments. Little business has been transacted of late in colliery steel, but it is anticipated that the demand in this section will revive in the early autumn. Light arches are quoted at £8 5s. and heavy at £8 15s., with roofing bars at £6 10s. to £7 5s., according to thickness. In South Wales business in iron and steel appears to be expanding. Steady conditions rule in the tin-plate department, and in South Wales this sets the tone of the whole steel market. The demand for semis is not quite so strong as in the later part of July, and consumers are showing a tendency to hold back their purchases.

Current Business.

The Chesterfield Tube Company, Ltd., has received an Admiralty order for steel for oxygen cylinders. The Italian Government has awarded a contract for the supply of a large distillation plant for use in East Africa to G. and J. Weir, Ltd., Glasgow. The Darlington Fencing Company, Ltd., of Doncaster, has obtained a contract from the War Office for wire fencing. The Vulcan Foundry, Ltd., Newton-le-Willows, has secured orders for eight steam locomotives and tenders for China; twenty-one boilers for the Madras-Mahratta Railway, and several large boilers for the Egyptian State Railways. Lithgows, Ltd., Port Glasgow, have obtained an order for a motor vessel of 9000 tons d.w. The engines are to be built by John G. Kincaid and Co., Ltd., Greenock. The Glasgow Corporation has under consideration the erection of a new bridge over the Clyde between Finnieston and Plantation. About twenty firms have been invited to tender, but it has not yet been decided whether the bridge will be of ferro-concrete or of iron and steel. The cost is expected to be £1,200,000, of which £400,000 has been spent on the purchase and preparation of the site. The Department of Overseas Trade reports that the following contracts are open for tender:—Cape Town, Electricity Department: Two sets of automatically controlled, electrically-driven sewage pumps, motors, piping, &c. (Cape Town, September 25th). New Zealand Posts and Telegraphs Department: 10 tons of 150 lb. per mile hard drawn copper wire (Wellington, October 15th). Dunedin City Corporation Tramways: 100 tons of tramway rails, &c. (Dunedin, September 27th). New Zealand Public Works Supply and Tenders Committee: Car haulage gear and control equipment for an automatic passenger and goods lift (Wellington, September 17th).

Copper and Tin.

A feature of the electrolytic copper market has been the heavy buying by American consumers. In one day 69,000 tons was sold at 8c., this being the climax of a strong movement. The view of the market is that the purchases were inspired by the knowledge that the American copper producers had decided to raise their price from 8c. to 8·50c. d/d, and had made no secret of the fact. As a result, there was a general rush by consuming interests to cover their prospective requirements for some months ahead. After the price had been increased more normal conditions prevailed in the market. Consumers in this country and on the Continent also have shown more interest, although the export price has not advanced to the same extent as the American domestic quotation. Naturally, there has been a tendency for large users to safeguard their position in view of the disturbed international political outlook. Some British merchants who recently sold to foreign buyers are without their money and decline to do further business with these countries except on a payment in advance basis. Notwithstanding these obstacles to trade, the general tone of the market is stronger than for some time, and expectations are rife that a sustained upward movement will set in. The standard market has responded to the better demand for copper, but the advance has been more restrained owing to heavy profit taking at times. These offerings were freely absorbed and the undertone of the market remains sound. . . . The tin market has been fairly active, but the American buying which was a feature of the situation last week has subsided and the Continental consuming industries are taking comparatively little. The backwardation has widened to about £10, and this is regarded as an unsatisfactory feature. The prompt position seems somewhat easier than at the beginning of the month, but no great measure of relief is expected until the supplies resulting from the increase in the quota come to hand at the end of next month. According to the figures issued by the Hague Statistical Office of the International Tin Research and Development Council, the production of tin in the first five months of this year totalled 45,089 tons, an increase of 3032 tons over the production for the corresponding period of 1934, whilst the consumption showed an increase of 15 per cent. over last year, the figures being 56,243 tons, against 48,931 tons in 1934.

Lead and Spelter.

Interest in these markets centres upon alterations in the duties which came into force on August 27th. The duty on lead is now 7s. 6d. per ton, or 10 per cent. *ad valorem*, whichever is the lesser. The report of the Import Duties Advisory Committee states that the arrangements reached are embodied in two Memoranda of Agreement between the representatives of the producers and the consumers, and of the London Metal Exchange. The Committee may, at their discretion, after a further inquiry, recommend the suspension of the duty either upon lead or spelter after it has been in operation for one year, if they are satisfied that the London Metal Exchange price is likely for a reasonable time to remain at not less than £13 per ton for lead and £15 for spelter. The change over to the new duties had little influence upon the market, since the principal details had long been known. The demand has been well maintained and the consumption of lead by the lead pipe and sheet makers so far this month is said to be a record for August. Under the new arrangement the price of Empire lead will carry a premium of 7s. 6d. per ton over foreign metal. . . . In the case of spelter the duty has been fixed at 12s. 6d. per ton or 10 per cent., whichever is the lesser. Otherwise, the same conditions apply as in lead. The higher duty upon spelter is stated to be justified by the special circumstances of the home smelting industry, which has been established at heavy cost and constitutes an asset of great value to the country. Except as regards one grade of zinc, the price of Empire metal is left free for sales direct to consumers, but for delivery on the Metal Exchange it will be at a premium of 12s. 6d. per ton over foreign spelter on which duty would be payable by the buyer. It is specially provided that the price of Empire electrolytic brands of zinc of a purity of 99·9 per cent. up to but not including 99·99 per cent., shall not exceed £2 10s. per ton above the mean of the London Metal Exchange spot and forward quotations. The tone of the market has been firm, but the turnover has not been heavy.

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.; plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. Coast—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 10 6	3 2 0
No. 1	3 11 0	3 3 6
Cleveland— (*D/d Teesside Area*)		
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 10 0	—
Midlands—		
Staffs.— (*Delivered to Black Country Station*)		
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/– rebate*)	3 15 0	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
Scotland—		
Hematite, f.o.t. furnaces	3 11 0	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/– rebate*)	3 10 0	—
N.W. Coast—	3 14 6 d/d Glasgow	
Hematite Mixed Nos.	3 18 6 „ Sheffield	
	4 4 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
Lancs.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. Yorks.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
Midlands—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
No. 3 quality	7 10 0	—
No. 4 „	8 0 0	—
Scotland—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. Coast—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

London and the South—	Home.	Export.
	£ s. d.	£ s. d.
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 6	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	7 0 0
Flats, 5in. and under	8 14 6	7 0 0
Plates, ⅜in. (basis)	9 0 0	7 15 0
„ ½in.	9 5 0	8 0 0
„ ⅝in.	9 10 0	8 5 0
„ ¾in.	9 15 0	8 10 0
„ ⅞in.	9 10 0	8 5 0
North-East Coast—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 5	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ⅜in.	8 15 0	7 15 0
„ ½in.	9 0 0	8 0 0
„ ⅝in.	9 5 0	8 5 0
„ ¾in.	9 10 0	8 10 0
„ ⅞in.	9 5 0	8 5 0
Boiler Plates, ⅜in.	9 5 0	—
Midlands, and Leeds and District—		
	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ⅜in. (basis)	8 17 6	7 15 0
„ ½in.	9 2 6	8 0 0
„ ⅝in.	9 7 6	8 5 0
„ ¾in.	9 12 6	8 10 0
„ ⅞in.	9 5 0	8 5 0
Boiler Plates, ⅜in.	9 7 6	7 15 0

STEEL (*continued*).

Glasgow and District—	Home.	Export.
	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ⅜in. (basis)	8 15 0	7 15 0
„ ½in.	9 0 0	8 0 0
„ ⅝in.	9 5 0	8 5 0
„ ¾in.	9 10 0	8 10 0
„ ⅞in.	9 5 0	8 5 0
Boiler Plates	9 5 0	—
South Wales Area—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ⅜in. (basis)	8 17 6	7 15 0
„ ½in.	9 2 6	8 0 0
„ ⅝in.	9 7 6	8 5 0
„ ¾in.	9 12 6	8 10 0
„ ⅞in.	9 10 0	8 5 0

Ireland—	Belfast.	Rest of Ireland.
	£ s. d.	£ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ⅜in. (basis)	9 0 0	9 2 6
„ ½in.	9 5 0	9 7 6
„ ⅝in.	9 10 0	9 12 6
„ ¾in.	9 15 0	9 17 6
„ ⅞in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

	Home.	Export.
Sheets.	£ s. d.	£ s. d.
10-G to 13-G., f.o.r.	9 10 0	8 15 0
14-G. to 20-G., d/d	10 15 0	9 0 0
21-G. to 24-G., d/d	11 0 0	9 5 0
25-G. to 27-G., d/d	11 12 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £12 15s. 0d., c.i.f. India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel Ports, 18/2.
Tin-plate Bars, d/d South Wales Works, £5 5s. 0d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 to 250 tons	5 17 6
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£21 15 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 0 0	7/–
„ „ 8 p.c. to 10 p.c.	£21 0 0	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£34 0 0	11/–
„ „ „ 1 p.c. carbon	£36 5 0	11/–
„ „ „ 0·50 p.c. carbon	£37 5 0	12/–
„ „ „ carbon free	9½d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 15 0 scale 5/– p.u.	
„ „ 75 p.c.	£17 17 6 scale 6/– p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	4/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Cobalt	5/6 per lb.	

NON-FERROUS METALS.

Official Prices, August 28th.

Copper—		
Cash	£33 3 9 to £33 5 0	
Three months	£33 11 3 to £33 12 6	
Electrolytic	£36 15 0 to £37 5 0	
Best Selected Ingots, d/d Birmingham	£37 10 0	
Sheets, Hot Rolled	£64 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	10d.	10d.
„ Brazed (basis)	10d.	10d.
Brass—		
Ingots, 70/30, d/d Birmingham	£29 0 0 to £31 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	9½d.	9½d.
„ Brazed	11¼d.	11¼d.
Tin—		
Cash	£220 10 0 to £221 0 0	
Three months	£210 10 0 to £210 15 0	
Lead: Cash and forward	£16 0 0	
Spelter	£15 8 9 to £15 13 9	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

Lanarkshire—	Export.
(f.o.b. Grangemouth)—Navigation Uncreened	13/– to 13/9
„ Glasgow—Ell	14/6 to 15/–
„ „ Splint	17/– to 17/6
Ayrshire—	
(f.o.b. Ports)—Steam	12/6 to 13/–
Fifeshire—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	13/6 to 14/–
Unscreened Navigation	13/6 to 14/–
Lothians—	
(f.o.b. Leith)—Hartley Prime	13/6 to 13/9
Secondary Steam	12/– to 12/3

ENGLAND.

Yorkshire, Manchester—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	13/– to 16/–
Northumberland, Newcastle—	
Blyth Best	13/6 to 14/–
„ Second	13/3 to 13/6
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
Durham—	
Best Gas	14/8
Foundry Coke	19/– to 20/–

Sheffield—	Inland.	
Best Hand-picked Branch	23/– to 25/–	—
South Yorkshire Best	20/– to 22/–	—
South Yorkshire Seconds	17/– to 18/6	—
Rough Slacks	8/– to 9/–	—
Nutty Slacks	7/– to 8/6	—

SOUTH WALES.

Cardiff— Steam Coals:	
Best Admiralty Large	19/6
Best Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	12/6 to 13/6
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	27/– to 40/–
Furnace Coke	19/– to 22/6
Patent Fuel	21/–
Swansea—	
Anthracite Coals:	
Best Large	36/– to 40/–
Machine-made Cobbles	41/– to 48/6
Nuts	40/– to 48/6
Beans	25/– to 30/–
Peas	19/– to 23/–
Rubbly Culm	11/– to 11/6
Steam Coals:	
Large Ordinary	18/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

French Engineering Notes.

(From our own Correspondent in Paris.)

Small Aeroplanes.

FACILITIES for private flying are offered by a number of clubs throughout the country which are encouraged by the Air Ministry with the aid of subsidies, and the work done by those clubs is satisfactory within the limits provided by the financial assistance accorded, although they have always complained that their utility from a national point of view is seriously restricted by the parsimony of the State. The Air Minister, General Denain, has therefore revised the conditions under which the State will come to the aid of private flying and has, at the same time, sought the collaboration of aircraft firms in providing suitable machines. The high cost of small aeroplanes has been primarily responsible for the comparatively slow headway that has been made in extending popular interest in aviation. Only a few firms manufacture them, and as the demand for them is limited by the cost, there is little chance of their being constructed in quantities and reduced in price unless the State is able to bear a larger share of the financial burden. Under the new arrangement additional assistance is offered by the State, although it looks chiefly to the organisation of manufacture with a view to bringing down the cost of the machines. Instead of being a side line of some firms, the small aeroplane, with engines up to 40 h.p., should, it is held, be specialised. Its design is, at the moment, largely in the hands of amateurs who carry on their work by trial and error, with little relation to aerodynamics. Experiments with gliders fitted with small engines are helping the evolution of low-priced machines. While some small aeroplanes based upon these experiments have given encouraging results, a lack of scientific guidance suggests the need for caution on the part of users, particularly in view of several accidents that have occurred lately to a popular type of small aeroplane, for it is not known whether those accidents can be attributed to structural defects or faulty design, or even to the inexperience of pilots. Like all new departures, the early stage of small aeroplane development necessarily involves risk, and it is suggested that amateur invention should be controlled by technical knowledge and subjected to the same safeguards as the construction of bigger machines.

Rhine Navigation.

When the French Government decided to construct the Grand Canal between Huningue, opposite the Swiss frontier, and Strasbourg, and thereby avoid difficulties of navigation on the Rhine, the Governments of Germany and Switzerland prepared to undertake an alternative scheme of canalising that section of the river. Before the war the Grand Canal was an Alsatian project which the German Government refused to sanction, preferring the plan to canalise the river and remove the Istein rocks so that traffic could be continued all through the year between Kehl, the German port opposite Strasbourg, and Basle. Since Germany and Switzerland started upon this work, they have deepened the river and diverted the currents that silted the bed and made a channel 75 m. wide and 2 m. deep at lowest water level for a distance of about 49 miles. The most difficult task is to remove the Istein rocks, which are at present avoided at low water by the short Kembs section of the Grand Alsatian Canal. It is expected that the whole undertaking will be completed in 1941. In Alsace it is feared that these greater facilities for utilising the Rhine will seriously prejudice the port of Strasbourg, where, during the first half of the present year, the traffic has declined, while that of Basle has increased, and there has been a notable diminution of tonnage passing through the canal section at Kembs. Boats no longer transfer cargoes to lighter barges at Strasbourg, but proceed direct to Switzerland. Basle is also profiting from an increasing traffic on the Rhine. It is doubtful whether the Grand Canal will be extended from the Kembs section to Strasbourg.

The "Atlantique."

After the judgment condemning the British insurance companies to pay the full amount for which the "Atlantique" had been insured by the Compagnie Sud-Atlantique, the case was reopened by the underwriters on the ground that evidence could be brought forward to prove that the wiring installation on the ship was defective. The companies had based their claim partly upon the alleged existence of such defects which, it was stated, had been notified to the owners before the policy was signed, and it was only after judgment had been given by the French Courts that witnesses, who had been at work on the installation, came forward and testified to its unsatisfactory character. The underwriters' experts therefore made another examination of the burnt-out hull lying at Cherbourg and discovered some of the wiring that had survived the fire and revealed, it is claimed, the alleged defects. The magistrate who has charge of the inquiry thereupon appointed a naval engineer at Cherbourg to make a further investigation, and his report, now in the hands of the magistrate, is said to confirm the conclusions of previous French experts to the effect that there had been no criminal attempt to destroy the ship, which, however, is not the point raised by the insurance companies.

Trade with the British Empire.

Simultaneously with the publication of the returns of foreign trade during the first seven months of the year showing another low record of export values, which declined 11 per cent. while the tonnage increased 6 per cent., detailed figures have been made available of the trade done with foreign countries during the first five months of the present year. Imports from Great Britain totalled 798 million francs, compared with 867 millions, and exports to that country were 788 millions as against 764 millions. From the remainder of the British Empire imports into France were valued at 1156 million francs, Australia contributing 405 millions, British India 332 millions, Canada 176 millions, and South Africa 127 millions. French exports to the British Colonies and Dominions declined from 139 million francs to 109 millions.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

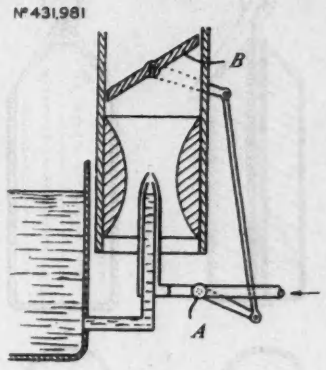
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

431,981. September 10th, 1934.—CARBURETTERS, P. Mondt, 10, Rue de la Livatte, Roanne (Loire), France; and R. Siriez, 13, Rue Burdeau, Roanne.

This carburetter is intended for heavy fuel oils and the atomisation is helped by an auxiliary supply of gas introduced by a tube surrounding the jet. This gas supply is regulated by a valve A interconnected with the main throttle B. The gas



N° 431,981

under pressure may be air or exhaust gases, as is known in carburetters operating with auxiliary pressure, the exhaust gases being, for instance, drawn from a sparking plug provided with a tapping attachment with a non-return valve. But the gas under pressure may also advantageously be an ignitable gas: lighting gas, hydrogen gas, butane gas, &c., in which case it improves the explosive properties of the mixture drawn into the engine cylinders.—*July 18th*, 1935.

432,108. January 17th, 1934.—COMBUSTION CHAMBERS, A. A. A. Darche, 245, Rue Edouard Vaillant Bondy, Seine, France.

The inventor says that his arrangement of combustion chamber checks detonation and consequently enables a higher compression ratio to be adopted. In this design, when the piston is near the top dead centre, the combustion chamber is divided into two separate chambers, the first of which is provided with ignition means, the two chambers communicating by a passage, formed between the cylinder head and the top of the piston, of small height, but of large surface area, which surface cools the gases passing therethrough, the propagation of the flame of combustion taking place through this passage, characterised in that the second chamber, without ignition

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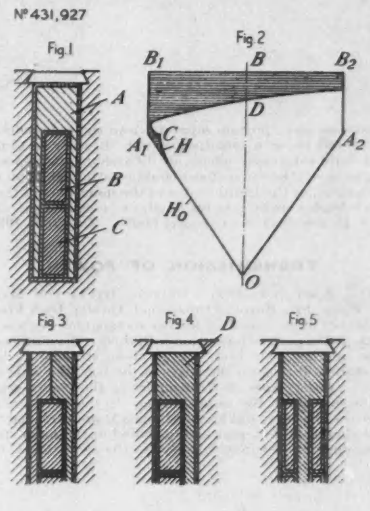
means, is disposed entirely in the cylinder head above the piston, and is thus entirely cooled by the water cooling the cylinder head, and is symmetrical about an axis parallel with the longitudinal axis of the cylinder, whilst the first chamber has its ignition means disposed at that side, thereof away from the second chamber, so that the flame of combustion travels without change of direction and is propagated by the above-mentioned passage in a direction sensibly perpendicular to the axis of the cylinder, until it undergoes at its entry to the second chamber an abrupt change of direction, sensibly equal to a right angle so as then to be propagated parallel to the axis of the cylinder. In the drawing the first combustion chamber is shown at A and the second at B. C is the admission valve and D the sparking plug.—*July 17th*, 1935.

DYNAMOS AND MOTORS.

431,927. March 21st, 1935.—DAMPING THE CROSS FLUXES IN THE SLOTS OF THE ARMATURES OF COMMUTATOR MACHINES, *J. T. Shevlin*, 15, *South-street, London, E.C.2.*

Various embodiments of damper plates to improve the current reversal of commutating machines by retarding the temporary variation in the flux across the slots are shown in the drawing. Thus Fig. 1 shows a damper plate which is in the form of an inverted U-shaped cap A arranged on the armature winding consisting of the top bar B and the lower bar C and extends from approximately the top of the slot opening down to the bottom thereof, the top portion being enlarged as compared with the portions located laterally of the slot conductors. The cap can, without affecting the function thereof, be composed of two pieces in the manner indicated in Fig. 3. Instead of the cap there can be provided, as shown in Fig. 4, a single plate having an enlargement D. If the plate is arranged between conductors which, under certain circumstances, may be advisable for an armature with two separate windings, then it is enlarged above the slot conductors on both sides, as is indicated in Fig. 5.

The method of operation of the above described damping device can be seen from the diagram Fig. 2. The cross induction H $_o$ produced by the armature current of the main winding has, at the commencement of the current reversal, that is, at the moment $t=0$, the form of the trapezoid O A_1 B_1 B; the whole transverse flux (per centimetre of armature length) φ is then represented by the surface of the trapezoid. With rectilinear current reversal, which can always be approximately attained under the effect of a suitable reversing field, this transverse flux alters if no damping (of current displacement) takes place, always from the form of O A_1 B_1 B into the oppositely similar form O A_2 B_2 B during the time of current reversal T. The current reversal potential there produced is $E\,r = -c\,\frac{2\varphi}{T}$, where c is a constant embracing the length of the iron, number of the turns, and the like. Under the influence of the damper currents produced by the field variation the transverse flux falls,

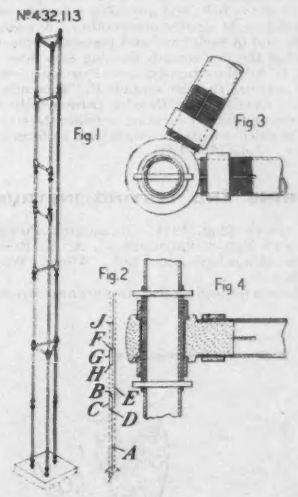


however, from its initial value of O A_1 B_1 B to the terminal value O C D and the flux variation is thus strongly retarded. If we term the hatched surface in Fig. 2 as φ', the damped current reversal potential created, namely, $E\,r' = -c\,\frac{\varphi'}{T}$. The reduction of $E\,r$ to $E\,r'$ and the actual gain in security attaching thereto, against spark formation, represented by the hatched difference surface in Fig. 2, depends, otherwise than on T, only in the addition of the cross section of copper of the damper and can, in practice, be carried considerably. A leakage in the usual sense as with wound coils does not take place, after the assumption made as to the course of the lines of force. A further advantage of the improved damper consists in the slot conductors being from the practical point of view entirely relieved of any eddy currents, so that solid bars behave, under the protection of the damper sleeve, like subdivided bars free from eddy currents, and show no appreciable additional losses even at high frequencies.—*July 17th*, 1935.

TELEGRAPHS AND TELEPHONES.

432,113. January 20th, 1934.—AERIAL SYSTEMS FOR SHORT WAVES, Marconi's Wireless Telegraph Company, Ltd., Electra House, Victoria Embankment, W.C.2; N. E. Davis, Openways, Little Baddow, Chelmsford; and F. J. Ainsley, 27, Lower Carnden, Chiselhurst, Kent.

This aerial mast is intended for the emission of ultra short waves and is intended for easy erection in exposed positions. It takes the form of a tripod braced together to be self-supporting.



It is sectionalised by insulators and connected together by some of the cross braces so that the aerial proper comprises the parts indicated alphabetically by the thick lines in Fig. 2. According to an important subordinate feature of the invention, the cross braces are located at and diagonal struts or tension members are arranged between points in the masts where the alternating voltage on the aerial portions proper is zero. The sketches Figs. 3 and 4 show the construction of one of the insulating strut joints.—*July 22nd*, 1935.

AERONAUTICS.

432,124. October 18th, 1933.—HELICOPTERS, O. Asboth, 1, Gower-street, London, W.C.1.

This invention relates to aircraft of the helicopter type and has for its object to provide aircraft capable of rising vertically from the ground or other resting surface and of descending vertically, of hovering in a definite position, of moving forwards at a varying speed and of gliding descent with the engine switched off, the aircraft remaining stable under all conditions of flight. The power transmission gear to the lifting screws may be provided with a free clutch of any usual character, so that under the influence of the relative wind speed the screw will be capable of a higher speed of revolution than that which is possible when it is positively coupled with the engine. This free or auto-rotation

is a function of the angle of inclination of the lifting air blades. For this reason the angle of inclination of the blade from the axis of rotation outwards to a certain distance will advantageously be 0 deg., and with this object the blades are so constructed as to be capable of differential setting of one part of the blade with respect to the remainder. For example, the blade

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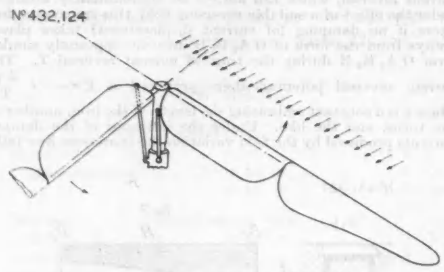

may have an inner portion separate from the remainder, which can be tilted about a longitudinal axis in order to obtain the desired auto-rotational effect at different flying speeds and gliding angles. The same object could be attained by an aileron-like formation of the trailing edge of the inner part of the lifting air screw blades, or by relative axial, *i.e.*, longitudinal, displacement of the members of a two-part blade.—*July 18th*, 1935.

TRANSMISSION OF POWER.

431,928. April 2nd, 1935.—DRIVING BELTS FOR MACHINES, J. Egan, 149, Harold's Cross-road, Dublin, Irish Free State.

A number of strands A of leather rectangular in cross section are arranged in parallel formation with their wider surfaces touching one another. On each side of these strands are laid two other strands B to form the edges of the belt, the wide surfaces of which are in planes at right angles to the planes containing the wide surfaces of the main strands. In the edges are secured a number of rivets C and leather thongs D are threaded through suitable holes, drilled, punched, or bored in the main strands A and the ends are securely fastened to the rivet pins C between

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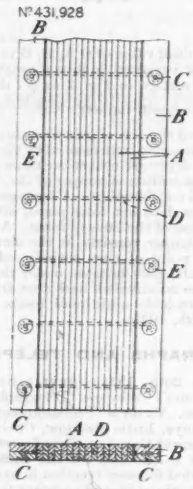

the two side strands so as to connect each pair of rivets on opposite sides of the belt, and are given a tension so as to keep the main strands tight against one another. A washer E is then placed on the end of each rivet and pressure applied to squeeze tightly together the two strands forming each edge of the belt. The thongs D are thus tightly locked or anchored round the rivet pins C between the side strands B. The ends of the rivet pins are then riveted over, thereby permanently maintaining the thongs taut and tightly securing together the strands forming the belt. For thicker belts the edges may be formed of three or more strands.—*July 17th*, 1935.

MEASURING AND TESTING INSTRUMENTS.

432,118. January 22nd, 1934.—MEASURING POWDERY MATERIALS INTO EQUAL PROPORTIONS, A. G. Rose and Rose Brothers (Gainsborough), Ltd., Albion Works, Gainsborough.

This machine is for feeding dry powders into cartons, or similar

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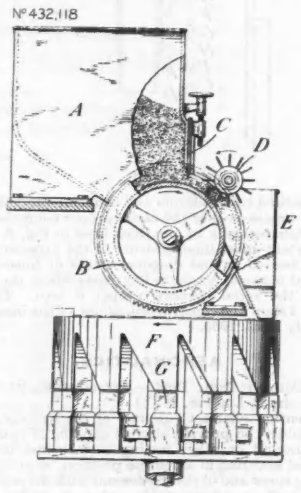

receptacles, in measured quantities. The powder is drawn from the hopper A and falls on to the drum B. The side flanges of this drum fit snugly against the sides of the hopper, and a measured stream of powder is drawn under the adjustable weir C. The spiked wheel D serves to keep the stream in motion. The powder falls into a shoot E, which guides it into a series of triangular shaped hoppers on a horizontally rotating wheel F. Beneath each of these hoppers there is one of the cartons G which are to be filled. It is claimed that as the stream of powder is constant and as the hoppers move at a uniform speed the powder will be apportioned equally.—*July 22nd*, 1935.

SHIPS AND BOATS.

432,104. December 21st, 1933.—SHIPS' FENDERS, O. J. Phillips, 30, Churchways-avenue, Horfield, Bristol.

A fender made in accordance with this invention consists essentially of a moulded rubber core which may contain a certain proportion of sponge rubber and which may be strengthened by the incorporation of a layer or layers of woven material, such as canvas or rope, and may have as an integral part a means of attachment to the ship. An example of one form of fender made in accordance with the present invention is as follows :—The fender consists of a cylindrical body of sponge rubber built on a mandrel with a layer of a tough abrasive-resisting material on the mandrel and covering the outside. On removal from the mould, therefore, the fender has a tough non-abrasive surface on

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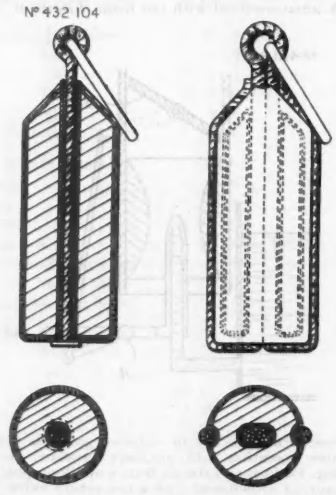

its outside where it will be subject to wear and stress between ship and quay and on the inside where it may be subject to stress from the means of attachment. A suitable mixing for the sponge core consists of 60 per cent. of rubber, 5 per cent. of zinc oxide, 20 per cent. of petroleum and oils, 10 per cent. of ammonium bicarbonate and sufficient sulphur and accelerator to effect vulcanisation under the conditions specified below. For the non-abrasive surface a mixing containing 60 per cent. of rubber, 30 per cent. of carbon black, 4 per cent. of zinc oxide, and sufficient sulphur and accelerator for vulcanisation would be suitable. Vulcanisation is carried out in a specially constructed mould designed to perform all operations in one stage. Heat only has to be applied, as the pressure of gases evolved from the inflating ingredients will be sufficient to expand the fender to the dimensions of the mould.—*July 22nd*, 1935.

MISCELLANEOUS.

432,116. January 20th, 1934.—VENTILATING INSTALLATIONS OF RAILWAY AND OTHER VEHICLES, J. Stone and Co., Ltd., Deptford; and J. F. B. Vidal, 48, Woodcrest-road, Purley, Surrey.

This heating system for railway coaches is automatic in action and is so devised that the ventilating fan will not waste current from the battery while the coach is lying idle in a siding. The steam heating coil is shown at A, the ventilating fan motor at B, and another motor for operating louvres in the ventilating duct at C. The connections with the battery and dynamo, not shown, are indicated at +B and +C. There is a common negative. Under summer conditions, the coil A is disconnected and cold, the switch D is in the position illustrated, and the fan motor B is automatically switched on and off by the switch E solely in accordance with the activity or inactivity of the axle-

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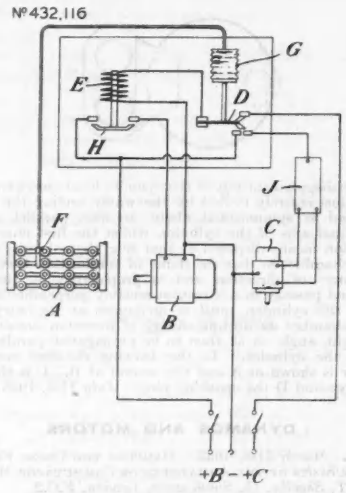

driven dynamo. Under winter conditions the coupling up of the locomotive with the vehicle, and the opening of the steam connection, results in a sudden heating of the coil A, which influences the thermostat bulb F. The expansion effect transmitted from the bulb to the bellows G results in the reversal, *i.e.*, depression, of the switch D whereby the winding E is energised from the battery and the fan motor B connected through the switch H, which automatically closes, across the battery terminals +B and —. Thereupon the fan motor drives the fan for the induction of air over the heating coil and into ducts which supply the vehicle. At the same time the circuit of the thermostatic regulating means J is connected across the battery so that the reversible motor C may operate, in accordance with the instant temperature, to cause more or less air to pass over, or by-pass, the heating coil A. When the locomotive is uncoupled from the vehicle or when its steam connection with the vehicle is interrupted, the thermostat bulb F will cool and permit the return of the switch D to the original upper position in which the temperature regulation through the reversible motor C is cut off and the circuit between the winding E and the dynamo terminals is restored.—*July 22nd*, 1935.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

SATURDAY, AUG. 31ST.

BELFAST ASSOC. OF ENGINEERS.—Annual golf competition and bowls match. Golf competition at Castlerock, depart Belfast 9.45 a.m. Bowls match at Portrush, depart Belfast 12 noon.

WEDNESDAY, SEPT. 4TH.

MANCHESTER ASSOC. OF ENGINEERS.—Visit to the East Lancashire Paper Mill Company, Ltd., Radcliffe, near Manchester. 2.30 p.m.

WEDNESDAY, SEPT. 4TH, TO WEDNESDAY, SEPT. 11TH.

BRITISH ASSOC. FOR ADVANCEMENT OF SCIENCE.—Meeting at Norwich.

THURSDAY, SEPT. 5TH.

INST. OF MARINE ENGINEERS.—Visit to Metropolitan Vickers Electrical Company's Trafford Park Works, Manchester.

MONDAY, SEPT. 9TH, TO THURSDAY, SEPT. 12TH.

INST. OF METALS.—Autumn meeting and Conference at Newcastle-upon-Tyne. For programme see page 99, July 26th, 1935.

TUESDAY, SEPT. 10TH.

INST. OF MARINE ENGINEERS.—85, The Minories, E.C.3. "Marine Electrical Installations in Service," Mr. H. G. Leivesley 6 p.m.

THURSDAY, SEPT. 12TH, TO SATURDAY, SEPT. 28TH.

SHIPPING, ENGINEERING AND MACHINERY EXHIBITION (INCORPORATING THE FOUNDRY TRADES EXHIBITION).—Olympia, London, W. Open 11 a.m. to 9 p.m. daily (except Sundays).

FRIDAY, SEPT. 13TH.

RAILWAY CLUB.—At Royal Scottish Corporation Hall, Fetter-lane, E.C.4. "Power-operated Signals," Mr. E. Wallis. 7.30 p.m.

MONDAY, SEPT. 16TH, TO THURSDAY, SEPT. 19TH.

IRON AND STEEL INST.—Autumn meeting at Manchester. For provisional programme see page 189.

WEDNESDAY, SEPT. 18TH.

INST. OF MARINE ENGINEERS.—Official visit to the Shipping, Engineering and Machinery Exhibition at Olympia, London, W.

THURSDAY, SEPT. 19TH, TO SATURDAY, SEPT. 21ST.

NATIONAL SMOKE ABATEMENT SOC.—Seventh annual Conference at Bristol.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MACROME, Ltd., have removed from 123, Sand Pits, Birmingham, 1, to Macrome Works, Berkeley-road East, Hay Mills, Birmingham.

JAMES HODGKINSON (SALFORD), Ltd., have changed the address of their London office to Brettenham House, Lancaster-place, Strand, W.C.2.

THE INDEPENDENT PNEUMATIC TOOL COMPANY, Ltd., London, S.W.1, informs us that Mr. Charles Findlay and Mr. John Robertson have been elected to the board of directors of the company.

SHORT AND MASON, Ltd., London, announce that they have purchased the business of S. and A. Calderara, previously of Springfield Works, London. Mr. A. E. Calderara, the late proprietor, is joining the company, and his plant, equipment, *personnel*, and technical staff, are being merged into its organisation.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

SULZER BROS. (LONDON), Ltd., have received an order for a 3400 b.h.p. heavy-oil marine engine and three auxiliary engines of 106 b.h.p. for a motor cargo vessel being constructed by Ateliers et Chantiers de France. An order has also been placed with them by F. Schichau of Elbing for two 4000 b.h.p. main engines for a motor vessel.

BRITISH INSULATED CABLES, Ltd., have recently received an order for 28 miles of copper contact wire, 52 miles of copper line wire, and 21,000 rail bonds, for extensions to railway electrification in the Bombay area. Other overseas orders include 20,000ft. of alloy sheathed cable for Hawaii, and 7120 yards of H.S.L. cable for Melbourne with special steel reinforcement, steel tape armour and corrosion proofing finish. Home orders include special fittings and 85 tons of cadmium copper trolley wire for London trollybus services, and 200,000ft. of aircraft cables for two well-known aircraft manufacturers.

THE L.M.S. RAILWAY announces that an order has been placed with Vickers-Armstrongs, Ltd., Barrow-in-Furness, for the supply of Erith-Roe mechanical stokers for two boilers on each of the Heysham and Belfast steamers "Duke of Argyll" and "Duke of Rothesay." The contract includes the fitting of "Vortex" grit arresters to the funnels. A contract has also been placed by the L.M.S. Railway with Mather and Platt, Ltd., Manchester, for the provision and fitting of "Grinnell" automatic sprinkler and fire alarm systems on these two vessels and on the Larne and Stranraer steamer "Princess Margaret."

MERRYWEATHER AND SONS, Ltd., Greenwich, have received from the Borough Council of Douglas, Isle of Man, an order for a motor turntable fire escape with all-steel ladder to extend to a height of 100ft., and fitted with life-saving apparatus, telephone, and searchlight. It will also be fitted with a powerful fire pump delivering 400 gallons per minute and operated either simultaneously with or independently of the ladder movements by power from the petrol motor which propels the machine. In addition, the company is to supply to the Council a motor fire-engine and a "Hatfield" trailer fire pump, and a foam generator for oil fires.